TX
345
C81
1967

Cornell University Library
TX 345.C81 1967
Speeches presented at the Cornell Confer
3 1924 003 533 159
mann

ALBERT R. MANN
LIBRARY

AT

CORNELL UNIVERSITY

TX
345
P31
1967

Scene at the Conference on New Foods, Flavors, and Analogs at Cornell University, April 24-25.

Hors d'oeuvres made of new food products.

Dried shrimps are reconstituted.

# CHANGING CONCEPTS OF FOODS AND THEIR SOURCES

Charles E. Palm, Dean
New York State College of Agriculture
Cornell University

We recognize that the topic--New Foods, Flavors and Analogs--is not a new one, but we do feel it to be timely. Recent conferences in all segments of the food industry have viewed it, and it is quite likely that increased attention and concern for new foods, substitutes, and synthetics will concern all of us.

I should like to say that the New York State College of Agriculture has a strong commitment to the food industry. Not only has it continued its traditional role of training students to work in the industry, but its research on production of quality raw products and new processing has expanded; it has explored the role of technical assistance through extension activities with the food industry itself.

The expansion of the program in food distribution and marketing is an important and growing area of the College of Agriculture's interest and responsibility. In fact, the total agricultural business complex, spearheaded in our Department of Agricultural Economics, is one of the two most important growth areas for student interest.

## Food Science Institute

The other is biological sciences, a resource that the University is strengthening through its recent organization of a Division of Biological Sciences. Agriculture currently has a commitment that involves nearly three-quarters of the permanent support of this division.

An effort is in progress to reorganize our resources from the Geneva and Ithaca campuses of the College of Agriculture to provide administratively a Food Science Institute that will strengthen our programs, provide additional faculty and physical resources, and establish greater working relationships and communication with the marketing and food distribution programs of the college and other related interests in the University.

We have had excellent support from the State of New York and from the industry itself in looking at the type of program we might develop that will be of most service to the food industry in the future.

Our expanding research in post-harvest physiology is being accepted as a means for maintaining high quality of fresh products. I mention these points briefly to assure you of our keen interest and deepening involvement in programs that relate to food.

## World Food Problem

We should recognize, it seems to me, another important force that involves the University as a partner in the complex that deals with it--namely, the growing demand for an adequate world food supply. Fortunately for us as consumers, the problem is not acute today, but one need travel only a short distance beyond our borders or to the far reaches of the earth to see that undernourishment and starvation are rampant in too many areas. This mounting problem must be faced realistically, and many efforts are being made to utilize our total resources.

We feel that agriculture in our nation has been fortunate in evolving a strong productive base--the commercial farm which has few rivals anywhere. Working as partners in the development of modern agriculture are industry, appropriate agencies of government, foundations, and the universities. These combined resources have effectively brought to our consumers a wholesome and abundant food supply at reasonable prices.

I believe that the same team of allied interests will help to develop indigenous food production in many countries of the world. This concern is being looked at in depth by the management levels of industry through several symposia scheduled for Chicago and New York during the months immediately ahead.

We cannot escape the overriding importance of meeting the world food needs. They must come in ahead of industrialization, another concept that has changed over the past decade in some developing nations.

## Agricultural Situation at Home

Let's look at the agricultural situation at home today. Over the past few years, this nation has moved from its position of being plagued by surpluses to the current one of seeing surpluses of the major food commodities vanish to safe levels of reserves, with a growing export market for hard dollars as well as increased commitments to the needy nations in keeping with our foreign aid programs.

Surpluses of wheat, butter, dried milk and other dairy products, corn, and others are continuing to drop. The government is requesting increased production in a number of commodities. Witness the public concern over the effect of adverse weather on the winter wheat crop in the Midwest and the dilemma of whether too small an acreage of feed grains is being planted in the coming season.

For the present, the era of burdensome surpluses is ended, and many unfilled grain storage bins around the nation are now of concern. I would identify the necessity for the farmer to share equitably in the value of his production.

## Backbone of Productivity

The number of commercial farms continues to decline. Less than a million farms in the recent census are producing 80 per cent of the raw agricultural commodities. These fewer but larger farm businesses are the backbone of our productivity, and must be serviced by allied industries for inputs and for the services of processing, marketing, and distribution of commodities to the consumer.

The increasing number of rural residents can no longer be called farmers; most are people who wish to live in the country but make their livelihood elsewhere. Their problems do intertwine with those of commercial farmers, however, and both groups have need for understanding and communication.

As we look to nutritional needs of humans and other animals, the discussion of protein supplies always comes up. There are those who point out that, in terms of our protein supply, it is wasteful to feed protein to animals. It is estimated that 23 per cent of the protein fed to a cow is recovered for humans; that 12 per cent of the protein fed to hogs is recovered for humans, and that only 10 per cent of the protein fed to steers is recovered for humans.

Another comparison is that an acre of land will produce for human nutrition only a quarter as many calories when the plants are fed to animals as when they are consumed directly.

## Proteins from Plant Sources

High quality proteins from plant or synthetic sources are essential to human foods in the future. To provide the quantities of protein needed, a great search is being conducted in many parts of the world. Microbiological production from fossil fuel is being investigated. High protein corn developed at Purdue University opens an important avenue for adding to quantity and quality of amino acids in a cereal that is so important in human nutrition. Already geneticists are seeking ways and means to improve the amino acid content of wheat, rice, and other cereals, since they figure so prominently in the diets of the human populations around the world.

The high protein content in soybeans continues to be used more diversely than any other crop; other legumes are being explored. The use of peanuts in some areas of the tropics received a setback because of the association of toxic products of fungi associated with the nuts when stored under hot, humid conditions. It is possible that improved technology may be able to minimize this problem.

For soybeans alone, it is estimated that the amount of protein is more than four times the total from all animal sources combined. Small amounts of supplemental amino acids are needed to make soy protein of higher quality, nutritionally speaking.

## Food from the Sea

The new era of food from the sea is likely to increase protein supplies through improved harvest of fish and other plant and animal life. Our new sea grants for research and development at the university level, as well as the expanded research in oceanography, can provide thrilling chapters in man's future.

May I say as a point of emphasis that the increase in research in the sciences basic to the technology of modern agriculture has been so rapid over the past decade, that one hardly knows the limit of its effect on what we often consider as agriculture's traditional role in providing the food supply. Agricultural research brings together many scientific disciplines. Today industry is investing more research dollars in agriculture than the combined state and federal support.

## Final Judge--the Consumer

Let's turn from the producer to the consumer for a few minutes. "Imitations," "synthetics," and "substitutes" no longer have the derogatory connotation once associated with the words. Increasingly everyone is aware that the consumer is the final judge. You can produce a product that, in your own mind, is superior in every way, but unless the consumer will buy it, you are lost. I don't recall specifically the mortality among new introductions, but it sticks in my mind that possibly eight out of ten new products never make the grade.

Furthermore, obsolescence is a high factor in the marketplace, where consumers are more and more willing to try something new. For one reason or another--convenience, price, difference, or other reasons--the consumer does consider some of the new foods to be superior to the originals. This fact is important to the producer who has to compete in this marketplace.

Another important consideration is prices. All segments of the food industry must be conscious of prices, for survival, if for no other reason.

The consumer, for example, is being given a choice between products such as butter and oleo; cream versus coffee whiteners; orange juice versus products like Tang and Awake. I read an article recently about the test-marketing of imitation milk on the West Coast; this product can retail at 39 cents a half gallon in supermarkets as compared with 49 cents for fresh milk.

## Other Factors Cited

Convenience is another consideration in the mind of the housewife and others who shop for food: Frozen orange juice versus fresh oranges; soluble coffee versus ground coffee; sterile canned milk versus pasteurized milk; processed potato products versus fresh potatoes; these are only a few examples. Likewise, the packaging of meals provides for expanded use of a variety of products in both home and institutional feeding.

Religion is another important consideration that influences the choices of foods. Meat versus vegetable analogs, as well as other choices, are well known.

Medical reasons influence the consumer's food choices. One thinks of diets immediately. (I know I should.) There is the problem of low cholesterol diets in relation to cardiovascular diseases. The rather recent impact of this on the milk industry is well known. The use of synthetic sweeteners, the dyclamates, saccharine, and combination versus natural sugar. Butter versus safflower margarine and ice cream versus mellorine are all examples that bring to mind the opportunity for choices among foods if health reasons are a consideration. I suppose one should include food fads as a consideration. Special foods for individuals with allergies are a factor, too. Soy milk in place of cow's milk is of particular importance to children who are allergic to the latter.

## Acceptance of New Foods

Consumer acceptance of new foods. There are a host of interesting facets to this complex series of events. How does one create a nutritionally balanced food product and introduce it into another culture--just because it is better nutritionally for the people than their present diet? How does one bring a synthetic or substitute product into successful competition with established products in our own economy?

Advertising certainly is one way that is being used to saturate the mind of the consumer with the fact that she, or he, does have a choice, and given that choice, why not try something new?

It has been reported that upwards of $5 million will be spent this year on advertising Tang and Awake. This is bound to have an impact on the beverage juice industry. It is reported also that $1.5 million will be spent for advertising coffee whiteners. This will further cut into what little remains of the cream market. New food products that imitate meats will gain an increasing share of the market for meats, especially as the price is reduced.

## Competition and Change

With New York State's agricultural production reaching nearly a billion dollars annually and the accumulation of another two billion in value as it is processed and marketed, we must try to understand the trends in the food industry and do our part in providing leadership through education and research. We are not against change; we favor it. We try constantly to fulfill our responsibilities to those we serve in a competitive society.

Competition and change are the cornerstones of progress that have characterized man's forward progress through the centuries. They will certainly continue and increase in a world that is expected to jump from three billion people to six billion within the next generation. We will need every conceivable method available to provide a total support for man's needs.

Despite opposition--physiological, legislative, economic, or other--substitutes for natural or established products have increased in numbers and importance. Chemical materials such as rayon, nylon, saccharine, cyclamates, corfam, drugs, plastics, and many others have signaled the entry of the pure synthetic into the competitive field. The food industry is deeply and increasingly involved in this competition. Production of agriculture as an important underpinning of the food industry, likewise, has high stakes in keeping its competitive situation.

I look forward to this program and I know we will find it stimulating.

# DAIRY PRODUCTS--MODIFICATIONS AND SUBSTITUTES

G. G. Quackenbush
Market Research Director
American Dairy Association

The problem of substitutes has connotations for all aspects of marketing, but I define it primarily as one of competition through research and development and a communications program. When a non-dairy product or a partial dairy product comes along to compete for the market for a dairy product, it can do so because it has one or more important attributes that the dairy industry does not provide.

Producing products with new attributes is a function of research and development. Telling the public that you have produced them is a communications program. Since research and development should be aimed at the consumer, I will call it a part of marketing. Certainly, the communications program is marketing, whether it be consumer education, advertising, publicity, point-of-purchase material, or something else.

My main point is that research and development and communications are the prime competitive methods these days, and that these methods of competition have been relatively neglected in the dairy industry and are being more neglected as time passes. Hence, there is a widening opportunity for substitutes.

## Substitutes for Dairy Products

Before developing this thesis, we might review briefly where we stand with substitutes for dairy products today. The butter-oleomargarine went from 3 pounds to 10.5. Total margarine has increased by six times; butter has been cut about in half. Substitute coffee whiteners are not dairy products. Though data are not available, I have seen estimates that they have about 35 per cent of the market--this in a few short years. Non-dairy whipped toppings are said to have 60 per cent of the market, leaving cream less than half. Both products are sold throughout the country. Mellorine has about 5 per cent of the frozen-dessert market, but it isn't growing very fast. The potential, however, is indicated by the fact that mellorine has about 40 per cent of the frozen-dessert market in Texas and 15 per cent in California. The product is sold in 15 states. Filled evaporated milk is made and sold in 4 states. It isn't moving rapidly, but it could be if evaporated milk itself were not dropping rapidly. A year ago, at the National Symposium on Substitutes and Synthetics, I stated that vegetable substitutes for fresh whole milk and cheese could be marketed, but that the amounts were not significant in the United States. Now, in California and Arizona a big test is on for filled milk. And people in other states are concerned. These are the obvious products, not to mention soft drinks, coffee, mayonnaise, cooking oils, and maybe even bucket seats.

## Big Business in U. S. Economy

Whether filled milk will be successful is anybody's guess at this time. It is my interpretation that what is going on now is a substantial market test. The crux of a market test is repeat purchases. It is possible that the filled milk may not achieve a high share of the market, but even a low share of a market these days is big business in this large American economy. Even at 5 per cent it would have as much impact as the large imports of dairy products are having these days, which at the 20 cent per hundredweight figured by Bill Knox cost the average farmer $500 last year.

At any rate, had not these various substitutes taken over the dairy markets, it is a conservative estimate that the dairy industry would have to be 25 per cent larger than it is now. So we have lost to these products nearly 25 per cent of our market in a little over 25 years. There are those who see the trend continuing, perhaps another 25 per cent in the next 25 years. I personally have made so many errors in forecasting that I am reluctant to make many more. I prefer to be more optimistic. The big ticket item, butter, cannot drop as far as it has on a per capita basis without going below zero, and I doubt that it will go to zero. Perhaps the big question is filled milk; its future is unknown at this time. And we should always remember that cheese is doing exceedingly well. Frozen desserts are doing well; sour cream is growing; cottage cheese is doing fairly well; and fluid whole and skim milks combined have been doing pretty well.

## Research and Promotion

Now let us return to the thesis. I started out by defining the problem of substitutes as primarily one of research and development (otherwise known as R and D) and of communications. And I said that substitute products offer consumers one or more important attributes that the dairy industry does not provide. It is the job of R and D to change product attributes; that is, in the product or package itself. It is the job of communications to change product attributes in people's minds; that is, their perceptions.

Oleomargarine obviously has offered a more favorable price attribute. But we tend to think this is the only attribute, whereas its shelf life, spreadability, fats composition, packaging, flavor, variety, and other attributes have gone through revolutionary changes, and its advertising and merchandising have been superb. Had the manufacturers defined their product by an act of Congress in 1923 as butter producers did, I'm sure the butter-margarine picture would be different. Had economists used these variables in their regression equations in addition to, or maybe even in place of, price and income, they would probably have obtained greater predictability.

Coffee whiteners offer longer shelf life, adaptability to freezing and drying, as well as lower price. Vegetable toppings offer these as well as the claim of double the quantity of whipped product and standing up longer after whipping. Mellorine and filled evaporated milk apparently have offered only one significant attribute, lower price, and have been less successful. I would predict that if filled milk offers only lower price, it too will be less successful. It could capture that segment of the market whose values are strongly price-oriented.

## Attributes Wrapped in Bundle

Two important considerations have been mentioned and should be developed at least to a minimum. First, a product has many attributes of value, hundreds of them, all wrapped in a bundle. There are the physical attributes (spreadability, whippability, blendability); chemical attributes (protein content, calcium, fats level, fats composition); sensory attributes (color, odor, feel, form, and sound); physiological attributes (refreshing, relaxing, filling, body-building, bone-building, fattening, slimming); economic attributes (price and value for the money); social attributes (what it does to you in the eyes of others--appropriate for the family, appropriate for guests, prestigious, flattering); psychological attributes (what it does to me in my own eyes--I am successful as a weight watcher; I am creative; I am a loving mother for having provided that birthday cake; I am imaginative for having persuaded Johnny to drink his milk; I am powerful for having made Mary drink hers.) A product is a tool for proving to yourself what you want to be.

Some of these attributes are changed in the laboratory; some in communications; some need both. The point is: a product is hundreds of attributes of value--not just a lot of nutrients at a low price--and the attributes are subject to change. Changing them is the No. 1 means of competition in today's economy.

The second point is that not all people value each attribute equally, and in an affluent society people can and do obtain attributes that they value, if not by one product then by another. It is this growing affluence and ability to express our individualism that makes R and D and communication the No. 1 competitive technique. Find out what people want, make it available, and tell them about it. This is modern industrial consumerism. It contrasts with professional consumerism emanating from government and some universities these days--that a lot of nutrients at a low price comprise the only thing of value and that this is the only thing people should value. Eat margarine and drink nonfat dry milk. With affluence and individualism you proliferate products, not necessarily 200 million variations of a product (one for each person), but in terms of market segments composed of groups of similar persons who value highly similar attributes of the product.

## Two Bright Spots

It is only an accident that a product that was optimum 25 years ago is still optimum. A product that hasn't proliferated in terms of offering a variety of attributes is a sitting duck. If you don't believe what I say, look at two bright spots in the dairy industry: cheese and frozen desserts. How many kinds and varieties and package sizes of cheese are there in the store you trade at now, compared with the one you traded in 25 years ago? How many kinds of cheese crackers, cheese pone, cheese this, and cheese that are in your store that were never heard of 25 years ago? Think of the varieties of flavors, packages, and novelties of frozen dessert. Now think of butter. Then cream. Then evaporated milk.

Back to segmentation. This is the job of fitting the attributes of the products to the values of the people. Some people are price nuts. Do you have something for them? Some people are food faddists; health threats and nutrition are their big concerns. Do you have something for them? Some people are gourmets, luxuriously satisfying their tastes and appetites. Do you have something for them? Some people are influenced primarily by taste and appearance of food, perhaps some home economists, for example, who doubt that people can eat just plain hamburger. Do you have something for them? Some families have half a dozen teenage gluttons. Do you have something for them? We could go on and on, but doesn't it indicate that the non-proliferated product is a sitting duck?

## Dairy Industry Apathetic

I have gone to this great length because I feel that the powers that be in the dairy business are apathetic on this topic. Our products are great as they are; leave them alone. They're natural, whatever that means, but it's great. They're real, whatever that means, but it's great. We're producer-oriented instead of consumer-oriented. If people don't believe what we believe, make them believe it. If people don't like some attributes of our products as they are, make them like them. We think that nutrients and price are the only important attributes. We have the nutrients, we say. We think the price is right. Where we don't have the nutrients at the right price, some in the industry just say--oh, well, the product is dead anyway. Haven't you heard this about butter? Perhaps even milkfat in any of its forms is considered dead by some. Being in the animal industry, maybe price and nutrients are our Achilles' heel. If we have a Cadillac, perhaps it should come fully equipped.

The second reason why I have tried to communicate the importance of this area of dairy marketing is that the responsibility is rapidly passing into the hands of producers instead of marketers, into the hands of those mostly production-oriented from those who are more consumer-oriented. R and D is big business. It is costly and risky. Big dairy companies are becoming big food companies, and the profitability and ease of R and D in other food areas push them out of R and D for dairy. This is especially true in our big ticket items--fluid milk and cream and butter--where about three-fourths of our milk output goes.

Why is R and D drying up in the dairy industry? I think we have to look at two things. First, the enforcement of anti-monopoly legislation is forcing the big dairy companies to become food companies. As non-dairy products become potential for R and D, resources go there because the costs of introduction of new products do not include drawn-out and costly court cases and the disadvantage involved in tipping your hand on new products to competitors which is also involved in fighting the legal barriers.

The next things to look at, if the R and D and the communication job are being tossed to producers by default, are the structure and motives of producers, producer organizations, and the public institutions that purport to serve them.

## Farmers Active in Marketing

Dairy farmers, through their organizations, are up to their necks in marketing. Dairy cooperatives function strongly in market power, prices, grades and standards, and efficiency. Dairy farmers support R and D through dairy technology departments in universities. They support agricultural economists in universities for market efficiency and pricing.

They are involved in consumer education through the National Dairy Council. They are involved in promotion and a small amount of R and D in the American Dairy Association. Take all the functions of marketing, no matter whose classification of functions, and dairy farmers are involved, putting their time and financial resources into them.

Every one of these activities has aspects that relate to substitutes for dairy products. Market power can legislate against them or provide other frictions to limit their success. Prices can encourage or discourage them. Increased efficiency can reduce prices to discourage them. R and D can outsmart them. Education, promotion, and other methods of communication can talk about the beneficial attributes of your products to discourage substitution. At any given time there is a proper balance of these efforts to restrain substitutes.

My thesis is that since the market power, pricing, and efficiency aspects have slipped in ability to be effective on substitutes and the R and D and communications aspects have been tossed to producers by default, the R and D and communications aspects need renewed efforts, both absolutely and relatively.

Time was when the market power aspect could handle substitutes fairly well. Legislation held margarine back for 50 years. We know what has happened since 1940. Farmers don't have the votes any more. And with substitute coffee whiteners it was not even possible to force them to label it imitation cream, a technique to cause friction in its acceptance. Market power in these respects isn't dead; it has slipped.

## Countermeasures Cited

Pricing and efficiency also have slipped. In an affluent society price becomes less and less of a concern. Other attributes become more important. It is said that the price elasticity of milk is approaching zero and income elasticity is, likewise. With very low price elasticity, the goal of efficiency comes into new perspective. After all, its chief objective is to get products to people cheaply. Prices and efficiency as aspects of the substitute question aren't dead; they have just slipped.

What can be done, or what should be done, if R and D and communications are to receive enough emphasis to have an impact on the substitute problem?

1) It will cost money. To be effective, it may take a minimum of one per cent of the producer's milk check for R and D and another one per cent for communications in the form of consumer education, advertising, merchandising, etc. That is $55 million yearly for each. I say one per cent for each with tongue in cheek, since I doubt that this is adequate.

2) A means would have to be found to assure full support for each program. Free riding could not be tolerated. Free riding by some would destroy the incentive for those who were willing to invest.

3) Cooperatives would probably have to take the leadership to get the job done. This would require a great widening of the scope of their major concerns.

4) A substantial change in attitudes would be needed from a producer-oriented to a consumer-oriented point of view. The products we have now are good, but we need some different products, if not better ones. This means opening the door to new and improved dairy products, not killing them as they are conceived.

5) A single national organization and facility separate from university and government may be required for the R and D programs. These programs must be highly practical and highly interdisciplinary. They also should be very selfish and competitive. Universities and government have difficulties in these respects. And the full-stomach philosophy that activities to expand the consumption of one product only diminish another to the detriment of all is an irrelevant one.

6) Competent organizations for the communications program exist in NDC for education and ADA for promotion. Coordination with R and D activities would be needed, and this would call for an expansion as well. For present products much larger budgets would be required.

7) A more unified feeling will be necessary in the dairy industry, both product-wise and geographically. It is not my impression that a shortage of fresh fluid milk in New York City or Chicago obtained the price increases in those markets in 1966. Nor was it the import of fresh fluid milk that cost the average dairyman $500 last year.

## Competition from Substitutes

This is one type of program that might be successful in meeting the competition from substitutes. An alternative, of course, wouldbe to open the doors for large dairy companies, the only ones who can afford R and D, to become effective and operative. This means a change in the rules of the game, so that not only would it be as easy to introduce a new dairy product or dairy product package as it is a new hair spray or a new glue, but the new item would be cheered by the producer element. Prospects for this look rather bleak. My impression is that the shift from producer orientation to consumer orientation by the producer element is more likely to occur if it gets actively involved.

A third alternative is to do what we're now doing. In the words of a USDA top brass--tell us how badly you are going to be hurt and we'll help you adjust out of the business. Many university personnel would take the same point of view. Are they right? They are smart people and have lots of Ph.D's. I personally don't buy it, and, furthermore, I assumed that my assignment was more nearly in the area of how you can compete against substitutes. I believe the best defense is a good offense. And we seem to forget that when substitutes come at us we could have substitutes for something else.

# THE IMPACT OF SYNTHETIC FLAVORS ON AGRICULTURE

E. A. Day
Vice President
International Flavors & Fragrances, Inc.

To one who has spent most of his life associated with the dairy industry and his professional career serving agriculture, the thought of synthetics competing with agricultural food commodities is always disturbing. This is conditioned by my knowledge of the impact of margarine and coffee whiteners on the dairy products market. These are two of the most significant substitutes on the market today. I have learned, however, that much could have been gained for the dairy industry, had its reaction to substitutes been different.

Today, we live in an era of rapidly advancing science and technology and in a highly competitive business community. Hence, the trend to synthetics and substitutes that we are experiencing will accelerate. This trend can be beneficial to agriculture if agricultural and business leaders are fully aware of the moving forces and provide direction for the changing agriculture that is forthcoming.

## Food Items to Increase

To fully appreciate the rate of change in the food and beverage industries, one need only to consider some frequently quoted statistics. At the end of World War II, a grocery store had approximately 1,500 food items on the shelves. Today, a large supermarket carries 8,000 different food items--ten years hence, this number is expected to exceed 12,000. Furthermore, half of the 12,000 items do not exist today. These statistics depict an affluent society that is willing to pay the extra cost for convenience (built-in maid service) and variety in foods. They also depict a food industry with the very advanced technological capabilities for developing synthetics and substitutes to satisfy convenience and variety automatically implicit in a list of 12,000 food items.

In the coming years, substitutes will become more significant in those food commodities where the potential market is worth the expensive risks for research and development, legal and marketing costs. This, of course, is now happening for the major animal commodities. The meat industry constitutes approximately a $30 billion market at the retail level. A company that is only moderately successful with meat substitutes could still have a $300 million market if it captured one per cent of the total market. Margarine has captured over 50 per cent of the butter market. Milk products represent an $11 billion retail market and, like meat, represent a lucrative target for a company with resources that can afford the risk to develop substitutes.

## Legal and Marketing Problems

Fruit and vegetables have not been as attractive targets for substitutes primarily because of the diversity of commodities, the low cost of raw materials, and the size of the market for each fruit or vegetable. Vegetables are a $5 billion market and fruits are $3.5 billion. So many different fruits and vegetables are represented that the risk in developing substitutes becomes correspondingly greater. Substitutes do exist and probably will increase for fruits and vegetables where the intended use is primarily for flavor, and where texture and color are not a significant requirement. Substitutes for citrus juices and synthetic fruit flavors are notable examples.

While substitutes will become more significant in the future, the trend will be hindered to some degree by technical, legal, and marketing problems. The most significant advance, I believe, will be confined to modifying basic agricultural food commodities to fit new product concepts. By application of new technology, the food manufacturer gives versatility and functionality to the basic food commodities. In the modern food industry, he must draw upon an expanding array of synthetic food additives to achieve success. An illustrative example is the potato. Today, the potato is sold fresh, but also as flour, flakes, granules, chips, frozen french fries, etc. Only a few years ago, the potato industry was economically depressed and entirely dependent upon a fresh-potato market.

## A List of Criteria

Here we have an example of a basic agricultural commodity that is readily processed in a variety of ways to give new products with unique texture, shape, and flavor. The application of new technology to product development has placed the potato industry in a healthy position. This could not have been accomplished without the use of synthetic food additives. It is interesting and understandable that, today, potato processors have a keen interest in synthetic potato flavors for addition to potato products.

The food manufacturer, when developing new products, has a check list of criteria he wishes to meet. Palatability, which deals with flavor, usually stands high on his check list. A food can be nutritious, wholesome, conveniently packaged, and priced right, but if its flavor is unacceptable, it is essentially valueless. Hence, the ability to provide flavor appeal commensurate with the product concept frequently is the knife edge on which success or failure is balanced for the food manufacturer. He must have the ability or capability to flavor his product successfully. He has no alternative because the processing and fabrications common to the modern food industry usually deplete, or are detrimental to, the flavor of the starting food material. Flavor enhancement, masking, or development usually is required. Flavors to satisfy these needs are available from two sources: natural and synthetic. Sometimes, the difference between a natural and synthetic flavor is difficult to define because it involves legal definitions and all of the subtleties associated therewith. The definition also varies among countries throughout the world. Usually natural flavors are from some source in nature--frequently from agricultural commodities whether it be plant or animal.

## Disadvantages for Natural Flavors

Natural flavors have a number of disadvantages in the modern food industry. First, since they are derived from natural sources, they are susceptible to variations inherent in nature. Due to methods employed for isolation from nature, the delicate flavor balance is altered, which limits their utility. Frequently, they are unstable and usually they are expensive. Until recently, natural flavors were the best choice for the food manufacturer because of labeling laws and the fears of consumer reactions to products with synthetic or imitation labels. This barrier is slowly disappearing; the consumer is accepting synthetics.

A second reason for prior reliance upon natural flavors was the lack of authenticity in synthetic flavors. They did not give the required flavor impact. Today, this problem is being solved through significant advances in flavor research. During the past two decades, we have witnessed the development of instrumentation and techniques that enable us to unravel the many intricacies of nature's flavor secrets. Today, it is possible to use the scientific approach for elucidation of flavor composition of foods. Thus, the first step in making a new synthetic flavor is to find out what chemicals constitute the natural flavor. These chemicals are then made by chemical synthesis, rather than by nature, and are blended by a creative flavorist, rather than by nature. In making the synthetic flavor, we essentially take over for nature. We believe we can improve upon nature with synthetic flavors just as scientists have done with synthetic fibers, rubbers, and plastics. We can build functionality into synthetic flavors, which is impossible to achieve with natural flavors.

## Flavors of Future

Functionality defines the flavors of the future. It means providing flavors with physical properties compatible with the food process (liquid, powder, microcapsules, water solubility, fat solubility, etc.) It can also mean stability--prevention of reaction with other food constituents, protection against autoxidation and enzymatic degradation. Functionality can mean authenticity, like the fresh fruit or freshly prepared standing rib roast. Finally, functionality can mean uniqueness of flavor--this gives product identity, an extremely important attribute in the competitive food industry. To achieve the flavor functionality required by the food and beverage industry of the future, synthetics are essential. Deterrents in the guise of food laws and food company fears of adverse consumer reaction to synthetic labeling will disappear. Synthetic flavors will no longer have the connotation of unnatural, less good, and possibly dangerous. They will become accepted to mean more reliable, less expensive, more abundant, and more functional. This adds up to better food products at a price the consumer can afford to pay.

This picture appears nice and rosy for the food manufacturer and the American consumer. But what about agriculture? What will be the effect of synthetic flavors on future trends? Certainly, there are qualified economists with better forecasts than mine, but I would like to share some of my views.

## World as Potential Market

To appreciate the overall impact of synthetic flavors, we must expand our thinking to encompass the world as our potential market. Flavors will not be the primary moving force, but they will enable progress in developing markets where none otherwise would exist. At present, 68 per cent of the world population suffers from some form of malnutrition. This figure is expected to increase rather than decrease; thus, the rich will become richer and the poor will become poorer. The major deficiency in diets of the underdeveloped areas is protein. To make up the deficiency, new sources of protein must be tapped and the production of protein from agriculture probably will have to shift to more efficient sources.

According to some forecasters, animal proteins will become too extravagant to afford because of the inefficient conversion of feed by animals. If these forecasts come about, it means major changes in food habits. This can be accomplished only by providing acceptable foods to replace or supplement the existing diets. Extenders for animal protein, such as vegetable proteins, fish protein concentrate, or microbial protein from petroleum will be used as fiber, texturized extruded products, and meals. Supplementation of diets means some alteration of the foods in use, and this will require flavoring. In underdeveloped countries, natural flavors are too expensive, and again synthetics will serve the need. For example, synthetic beef and chicken flavors are one-fifth as expensive as the natural flavors, synthetic strawberry is 1/20th as expensive, and the cost of synthetic raspberry is 1/28th the price of raspberry juice.

From the foregoing, it would appear that the overall impact of synthetic flavors would be a synergistic effect in developing new markets and new uses for basic agricultural food commodities. Certainly some synthetic flavors will have synergistic effects upon successful introduction of substitutes, but overall, the impact should be beneficial. They provide a versatile tool to the food manufacturer, which strengthens his flavor dimension in food processing. This, in turn, gives market stability to basic agricultural food commodities.

# MEAT-LIKE PRODUCTS FROM PLANT SOURCES

W. E. Hartman
Director of Research
Worthington Foods, Inc.

My talk will purposely be somewhat sketchy, so that it will cover a wide area of the controversial topic of applied synthetics. Meat-like products from plant sources have been called everything in the past and none of them complimentary. At present, they are called imitations, synthetics, meat analogs, or simulated products. Really, the textured plant proteins as we are currently using them represent a new technology that is the spinning of protein into textured filaments which can find wide application in the food industry. Actually, it is now possible to eat your shirt, if you want to, because these can be made from protein filaments and there are many possible applications in the use of protein filaments. At one time we made casein chips of spun protein on which you could put milk for breakfast. This should satisfy the dairy people.

## New Foods to Gain Stature

Research and development in synthetic foods is no longer a skeptical venture. Today, it is fast becoming an alarming necessity. Two basic and major problems face the world today--the world population explosion accompanied by the skyrocketing need for food. Synthetic foods are already a part of big business. Synthetic vitamins, synthetic amino acids, synthetic flavors and condiments all are now being used in both human and animal nutrition. Under normal development the synthetic food industry would gradually but eventually attain a stature to compete with natural agricultural products. But the present world food situation is critical and will not wait for normal development.

Industry and various government agencies here and abroad are urging a spread of technology to meet the coming crisis. It is estimated that approximately 4 million tons of amino acids a year or 10 million tons of high quality protein a year are needed by 1980 to close the gap between conventional food production and the minimum needs of the hungry two-thirds of the world's population.

When I attended the Mathematical Association Conference of the Western Hemisphere in Chicago, I was greatly impressed by the theme that ran through the entire conference of the great need for protein. Technology in agriculture and then in research when applied to South America increased their agricultural output by approximately 200 per cent in about 10 years, but at the same time the available protein per person had dropped more than 20 per cent. This is quite staggering when you see that we are not keeping pace with the rise in population.

## World Food Problem

Actually this group is probably much more aware of the fact that we are facing food shortages throughout the world and that we are much closer to them in the United States than we realize. The dairy industry is well aware that, quite recently, there has come upon the American marketing scene a synthetic or imitation of every natural dairy product produced. At present we have imitation cheeses, imitation sour cream, and even an imitation margarine, so you can see the theme marches on.

The dairy industry is also aware that there is a shortage of milk at present. We have reports from CARE offices throughout the world that they no longer can fill the requirements of various CARE offices. As you know, U. S. News & World Report reported that many dairymen are going out of business in Wisconsin and New York and throughout the nation; the farmers have decided that they want no more of the daily grind of milking cows. I feel that Cornell University and others--Rutgers, North Carolina, Oregon--are facing a problem of lending food science departments for much of our food technology. Our universities owe something to their constituency to keep pace and not to become politically or personally biased in the application of technology.

As population increases, there will be competition for food between man and his domestic animals. The process of obtaining animal protein is wasteful in terms of the protein required in animal feed. The protein returned by the cow and beef cattle is relatively inefficient.

An acre can produce 800,000 calories in the form of plants, but only 200,000 calories when the plants are fed to animals. Meat animals use roughly 600,000 calories from each acre's crop for their own metabolism. The most logical agricultural approach to the increasing world food problem is the use of legumes that live symbiotically with nitrogen-fixing bacteria and efficiently produce protein with less depletion of nitrogen from the soil.

## Legumes as Protein Source

There are numerous sources of protein. Yet, technically, it is obvious that legumes represent a most important source of future protein, and their utilization must dominate any discussion of man's use of plant proteins.

Nutrition authorities have stated that we must be able to supply sufficient amounts of proteins for all the world, and, in so doing, they will not be animal proteins. It seems unwise to ask a developing country to start an agricultural program of dairy cattle and grazing cattle because the land can be used more efficiently as well as completely.

Worthington Foods has been in the vegetarian protein food business for some 25 years. Primarily, the business was concerned with supplying such foods to consumers who had medical, philosophical, or religious reasons for wanting them. Early products were based on wheat proteins or "gluten." Worthington had accumulated considerable flavoring know-how by the time soy products such as flakes, toasted grits, and isolated protein became available.

## Vegetarian Protein Foods

One of the first Worthington products based on soy protein was a powdered milk-like product, Soyamel, which was designed primarily as a hypoallergenic formula for infants and children who were allergic to milk. This product is reconstituted with seven parts of water for use. More recently an operation in Madison, Tennessee, produced a double-strength concentrated liquid soy milk designed for infant feeding. These soy milk preparations, now in their infancy, as far as sales are concerned, are expected to be in great demand in the near future.

Now, in the meat analogs or in the simulated meat field, Worthington is perhaps the first company to actively explore this protein spinning technique which was developed by Robert Boyer. Mr. Boyer was an interesting, charming man, who, at the age of 18, took charge of Henry Ford's laboratories.

For the past ten years, Worthington has pioneered in the field of vegetarian protein foods, seeking suitable protein isolates for spinning, developing spinning technology, and formulating and adapting these spun protein fibers to end-products acceptable to the consumer. Nearly every meat or meat product has been fairly well simulated in experimental prototype products. A great potential and versatility exist in these soya fiber products because they can be formulated to any protein, fat, or carbohydrate level. Proteins may be blended to accomplish very favorable amino acid ratios. Vitamins, minerals, color, flavor, amino acids, etc., may be added as desired. (Acceptable simulated hams have been made, with less than one per cent fat.) Actually, the small and narrow field of plant-protein technology has scarcely been touched. We can look forward to many new, different, and exciting applications of the spun protein fibers in the not too distant future. Other techniques of extrusion and processing also are in the development stages.

## Milk and Meat Analogs

The present technology of spinning, as practiced by Worthington Foods, uses as a raw material relatively pure soy protein isolate obtained from Ralston Purina, Central Soya, or other suppliers. This soy protein is solubilized at approximately 20 per cent solids by raising the pH of slurry to 12.0. Relatively large quantities of horsepower are required because this is an extremely viscous mass. The spinning "dope," as it is called, is pumped through "spinnerettes," much the same as those used in the rayon industry. The filaments are extruded into a coagulating bath and the molecular structure oriented by the speed of the "take-away" reel which removes the fibers from the bath. These fibers are then washed and rinsed and formulated into various end-products. Color, flavor, and supplements can be added as desired. In this manner a product may be engineered to meet taste, texture, and nutritional requirements.

Since primary development work has been centered on milk and meat analogs, it might well be expected that there would be some concern in the dairy and meat industries. Such headlines as appeared in the DeMoines Register after the farm editor visited Worthington Foods might cause any industry to rise in reaction, "Synthetic Meat Products Challenge the Livestock Feeder." As a result, Iowa hog growers and one national livestock group are vigorously pushing for legislation to curtail the growth of meat analogs. Again I feel that there is somewhat of a wrong approach because plastics when they first came out were pretty horrible things, but we have an excellent plastic industry today. We can't kill something because we don't like it. There have to be basic agricultural and economic reasons for survival. I should like to think that rather than challenge the "like" appeal, this will complement the other industries and prove beneficial. I personally feel that there is adequate need for protein and that the high quality and the luxury-type protein will always find a place in the American market.

## Worries Are Unwarranted

The reactions from meat producers and processors, however, have been varied. Many major suppliers of meat products have visited Worthington Foods and were impressed with the operation. Farsighted meat companies see a future closely combined with the meat industry where meat by-products could be made into choice lean cuts by the use of textured plant protein fibers. The meat analog industry feels that the "worries" of meat people are unwarranted. Meat analogs can compete favorably only where meat cannot or does not intend to compete. It should be remembered that soybeans are a basic agricultural product and that they rank second to corn as a cash crop in the U.S. The protein from soybeans last year amounted to four times that from all animal sources combined.

It is felt that some of the early antagonism to meat analogs has now influenced the Food and Drug Administration to push for the labeling of meat analogs as "imitation." General Mills product Baco's was seized recently by FDA for incorrect labeling. The meat analog industry contends that these products are processed foods from a basic agricultural product, soybeans. Recently the meat analog industry met with very favorable response from FDA in establishing a standard of identity for textured plant-protein food. Our concern is much the same as that of any industry, that research and development will lead to excellent and economical products. We don't want someone to come in and lower the protein content to cheapen the image of the product. We want to maintain it; so again there will probably be imitation meat analogs.

The immediate market for vegetarian protein foods is still the religious-philosophical group, the medical specialty and health group, and the underdeveloped, "have-not" countries of the world. But regardless of the opinions of the present and of opposition or optimism, the fact remains that food, and especially protein, is in increasing demand and need. Whether they be called imitation, synthetic, or processed agricultural products, they will survive. Before protein from petroleum becomes economical, before microbiological or chemical synthesis of protein is practiced, it seems only logical to believe that soybeans will become our number one agricultural product and will supply an appreciable portion of the human food of the world in many new and different, yet highly acceptable, edible products.

# THE IMPACT OF NEW PRODUCT DEVELOPMENT ON AGRIBUSINESS

Russell W. Peterson
Director of Research and Development
E. I. duPont de Nemours & Co.

It's my objective today to relate to you some of the developments in the Du Pont Company which I believe are of considerable significance to agribusiness. But first a few comments about the nature of the world in which all of us are doing business.

Probably the most significant factor as we look to the future is the tremendous rate of change around us. This great rate of change has led to a serious management lag and to the failure of many of us to recognize adequately the world in which we live. Do you realize that knowledge in the world has been doubling every 14 years? It is estimated that if a chemist worked full time for one year reading new information on chemistry, he would have fallen five years behind during that one year. In our country we have quadrupled our expenditures for research and development over the past 10 years. Since on the average it takes about seven years from the time a new product is discovered until it is commercialized, it is apparent that we have yet to feel in the marketplace the impact of this great increase of R and D over the past 10 years. One thing is sure: The future is going to be much different from the present. And so we who are involved in planning for the future of our businesses must be careful not to be trapped into judging the future with the yardsticks of today.

## Zigging and Zagging

We are pretty much in the same position as the gunnery officer on a bobbing ship trying to hit a vessel over the horizon when the target is continuously zigging and zagging. We need to create a hypothesis about the future and plan a course of action accordingly. We need to develop a new statistical method to study the trends and project them into the future.

As I tell you some developments of the Du Pont Company over the past few years, I should like to have you keep in mind the trends that they illustrate--trends that probably will accelerate in the changing environment of the world around us.

As you well know, man is still dependent upon nature for most of the things he needs. In the whole history of man up until this century, little headway has been made in getting at nature's secrets. But in this century, scientists have made great strides in this area, as I think you'll agree. Probably the biggest contribution of the Du Pont Company in unlocking nature's secrets was the work of Wallace Carothers who learned how to hook small molecules together end to end to form the long chains we call polymers--much as Mother Nature does it. The work sparked research throughout the world and led to the Du Pont Company's major success with nylon and other synthetic fibers. Although nylon was introduced just 27 years ago, it is already one of the major fibers in the economy of the world.

## Total Use of Fibers Grows

Nylon has been followed in the Du Pont stable of fibers by Dacron (polyester fiber), Orlon (acrylic fiber), Lycra (spandex fiber), Nomex (nylon yarns), and hundreds of variations of these products. Last year the Du Pont Company sold one billion pounds of fibers, and 50 per cent of these were in products that did not exist six years ago.

We now have an entirely new yarn in the laboratory that shows a much higher level of combined esthetics and performance than anything previously known. We expect to sell it in 1968.

The synthetic fiber business grew 24 per cent a year over the past five years, while the market for other fibers grew 4 per cent per year. The availability of newer fibers has stimulated growth in the total use of fibers, but the basic reason for a sixfold rate of growth for synthetic fibers is our ability to tailor fiber products to the requirements of particular markets and unfilled needs. The Du Pont Company is spending $80 million this year on research and development to tailor new fibers to the needs of the market.

Let me give you some examples of the tailoring of fibers. Let's consider nylon first. I will give you four examples.

As you know, nylon got its start as a hosiery yarn and now is favored by women the world over. In recent years it became apparent that women wanted hosiery that fitted the leg more smoothly and snugly and was more comfortable. We men of course appreciate some of those things too. But to fill this need, Du Pont scientists learned how to produce a bi-component fiber--a fiber in which one side was made from one nylon polymer and the other side of the filament from a different nylon polymer. This product, which is called "Cantrece" (nylon) hosiery yarn, develops a high spiral curl when it is heated, and this provides the desired stretch and fit to give the desired hosiery. This product, as all of you women know, is now a popular hosiery yarn.

Another example is the development of a bulked continuous-filament nylon carpet yarn that has revolutionized the carpet business. Nearly all quality carpets were formerly made from wool. The short wool fibers were cut from sheep and cleaned, straightened out with a carding machine, and twisted with a high number of turns per inch to form a spun yarn for use in weaving carpets. Nylon fibers, because of their unusual durability and cleanability, appeared well suited for carpeting, but when processed into carpets by the technique used for wool, gave inferior carpets that were very expensive. By analyzing the requirements of this use, it was decided that if a satisfactory continuous-filament nylon carpet yarn could be produced, there would be no need to twist the filaments to obtain the necessary strength, and thus a very expensive operation could be avoided. If, at the same time, filaments with high crimp or curl could be prepared, then a product with very high bulk, and thus good floor-covering ability per pound, could be produced. Suffice it to say, this was done and the product was introduced in 1958.

## Carpet Industry Changes

The carpet industry was already undergoing a major change as a result of the advent of the tufted carpet after World War II. But the bulked nylon filament yarn, a sample of which I have here, markedly accelerated and extended this change. The bulked filament yarns provided low-cost tufted carpeting of high durability and easy cleanability, and provided for stable prices.

Nylon is now the biggest volume carpet fiber, having captured 44 per cent of the market. Carpets are now used more extensively throughout the home, schools, and offices. The growth has been so rapid that the total volume of broadloom carpets has doubled over the past five years. Wool, meanwhile, has been used to the same extent over the past five years as over the previous five years. In addition to nylon carpet fibers, the Du Pont Company has introduced an Orlon carpet fiber, type 33, which is especially tailored for this use and is now receiving marked success.

Another nylon fiber tailored for a specific market was nylon tire yarn. In early tires the rubber was reinforced with cotton. But with the advent of higher speed cars, heavy trucks, and airplanes, something else was required.

In the 1930's the Du Pont Company introduced a rayon tire yarn, Cordura, which was made from wood pulp and cotton linters, and which became the dominant reinforcement for tires. The high strength and impact resistance of nylon, however, made it a promising candidate for use. Fifteen years ago, after a number of years of work, nylon was introduced in significant volume to the tire industry. Its prime advantage is its greater toughness. It provides more safety than do other fibers. Today, 55 per cent of all tire yarn is nylon, and, by the way, the success of nylon tire yarn caused us to shut down the multimillion dollar plants we had built for producing Cordura.

## Cooler Tires Roll

The earlier nylon tire yarn, however, had one deficiency. It flat-spotted. This means that when the tire had been heated by running, and allowed to stand, a flat spot developed at the point where the tire touched the ground. When the car was again driven, a vibration resulted for the first few miles, after which the flat spot was run out. The Du Pont Company scientists have been working for several years to solve this problem and have recently introduced a new nylon, Type N-44, which essentially eliminates this problem. Because of the flat-spotting problem, nylon had not penetrated the market for tires for new cars. But now N-44 is moving into that market.

Still another type of nylon is Nomex, a special nylon polymer developed for uses where toughness and resistance to high temperatures are required. This product, which is now being marketed in limited quantities, is useful for clothing for pilots, firemen, car racers, and others who are exposed to the hazards of fire, and for such uses as ironing board pads and covers.

Nomex has been speedily accepted by racing drivers who recognize that its flame resistance could make the difference between life and death. We are now in the process of providing additional capacity for Nomex.

Now let me move to Orlon acrylic fiber and tell you of the success in tailoring it for a specific market. The behavior of wool has long been recognized as unique and outstanding among natural fibers. The desirable hand or feel of wool, and its high bulk, stem from a spiral crimp or curl in the fibers. The ability of wool fabric to be finished to obtain a wide variety of surface properties comes from the characteristic of wool fibers to decrease their curl when wet and to increase it again when dried out. As a result, the fibers squirm and move around as the fabric is wetted and then dried. Man has tried for years to duplicate this performance with synthetic fibers.

## Sweater Is Engineered

The first truly synthetic fiber to have a working crimp similar to wool was put on the market by Du Pont in 1959. It is called Type 21 Orlon acrylic fiber. This fiber was produced by building into it the bi-component structure that characterizes wool fibers. One side of the wool fiber consists of a somewhat different polymer from that of the other side of the fiber. Since one of these polymers increases in length more than the other side when it is wetted, the fiber bends or curls as its moisture content is changed. By producing an Orlon fiber of two components that respond in length to changes in moisture content as do the components of wool fiber, a material was obtained that behaved like wool.

Thus we have another example of engineering a fiber to meet the requirements of desired uses. A sweater of Type 21 Orlon has a character very much like wool but at the same time provides the wash-and-wear and ease-of-care properties of Orlon.

Another of Du Pont's fibers that has had phenomenal growth is Dacron polyester fiber. Dacron is known primarily for its resistance to wrinkling and its ease-of-care properties. I was closely connected with this development from its beginning to its commercialization. In fact I picked my first cotton on the site in eastern North Carolina where the first Dacron plant was built, and then went on to become assistant manager of that plant.

This was the first industrial plant built in that area and I will never forget the impact it had on the community. Of the 2,000 employees hired in the early years, most of them had previously been employed on farms. It was amazing how these men in a few weeks mastered the operation of complex equipment and did an outstanding job of running this modern plant. In a few years the neighboring community, with its new homes, new schools, new churches, and new cars, showed the major impact of this new enterprise on the economy of that area.

One of the most interesting developments involving Dacron is its use in blends with cotton. Shortly after Dacron had been introduced, it was discovered that a blend of 65 per cent Dacron with 35 per cent cotton had a combination of properties for wearing apparel that was highly desirable and could not be provided by either component alone. The blend gave comfort, appearance, and ease of care that led to the sale of many millions of garments such as shirts, blouses, dresses, slacks, and undergarments.

## Leaps and Bounds

More recently this blend has led to another revolution in the textile business --the development of permanent-crease garments or permanent-press garments. Cotton interests for years have been working with the resin treatment of cotton to obtain wash-and-wear fabrics. Although it was possible to build substantial wash and wear into cotton fabrics by such treatment, invariably the treatment led to serious weakening of the cotton fibers. However, when these treatments were applied to the Dacron-cotton blend, it was possible to obtain outstanding resistance to wrinkling and a permanent press, while retaining good fabric strength.

As you know from your own shopping experience, permanent-press garments made from resin-treated Dacron-cotton blends have been growing by leaps and bounds. In fact, this development appears to be the fastest growing one in the textile industry today.

At the same time, however, research continues throughout the country to produce a suitable all-cotton permanent-crease fabric. Who knows what this will lead to? Success in this endeavor would give the synthetic-fiber producers a real challenge.

Another case of ingenuity in making fibers was the development of Lycra spandex fiber. Du Pont worked on this for many, many years before achieving an adequate product. I think you'll all agree that the previous stretch yarns made with a rubber base--rubber from the rubber tree--led to very bulky and nonaesthetic garments. To produce such a yarn with appropriate strength, it was necessary to use a fair-sized piece of rubber and to wrap it with cotton or with nylon to provide the proper abrasion resistance, appearance, and so on. When undergarments such as girdles were made of the covered rubber yarn, they were bulky, hot, and uncomfortable. This was true also for elastic hosiery. Many people who should have been wearing elastic hosiery were not doing so because of the poor aesthetics of the product available.

As a result of the development of Lycra spandex fiber, there now are available garments that are very sheer but have the withholding power to support a leg that has varicose veins, or the restraining power for use in a girdle.

Lycra has led to the development of a whole series of new fabrics. It has also been helpful in some older fabrics, such as those used in swim suits. This particular product has only 10 per cent of Lycra in it, but it provides highly desirable stretch and lasting recovery.

## Demisters Are Made

Another example of a fiber developed for a specific market was Teflon-TFE-fluorocarbon fiber. This is a fiber that has tremendous resistance to high temperatures and to corrosive materials such as acids. It's useful in places where no other fiber could be used.

For example, here is a small sample of a demister made up of knitted fibers of Teflon. Such demisters are made in units 10 feet in diameter. They can be used, for example, in chimney exhaust lines in sulfuric acid plants. The mist of sulfuric acid entrained in the chimney gases is condensed on the Teflon fibers and runs down to the bottom of the chimney, thus preventing contamination of the air and, at the same time, recovering a valuable product.

The newest of the major developments in the Du Pont Company's textile fiber business is the introduction of spunbonded materials. These are nonwoven materials produced by remarkable new processes in which the operations from basic chemicals to final structure are carried out in one continuous integrated step. For example, in one case, barges of basic raw materials are brought into a plant site and in one long train of operations without interruption go through to a roll of spunbonded material.

Three of these spunbonded materials are now in the works. A commercial plant has been started up for one--Reemay spunbonded material--and plants are being built for the other two.

Here is a sample of Reemay, made from Dacron polyester fiber. It has good properties of Dacron such as wash-and-wear, resilience, and dimensional stability. One of its initial uses is for inner linings in shirts and blouses. It gives neatness retention through repeated launderings. It's also very effective as a substrate in producing coated fabrics such as book coverings. The tests of book covering include a scrub test in which the book-covering material is rubbed on itself a number of times until some failure of the surface is observed. The book-binding material made with Reemay can be scrubbed five times as long as the best other competitive material before a failure occurs.

A novel hat is made by the Hat Corporation of America from Reemay by the technique used for making straw hats. They cut this sample of Reemay, which is easily dyed and printed, into one-inch strips and then made it into this so-called pocket hat. The objective is to carry the hat around in your pocket, take it out when you need it, and unfold it and put it on. I brought this sample in my briefcase but I think you will agree it looks good.

## "It" Hasn't a Name--Yet

Another spunbonded material--we haven't given it a trademark yet--is made from polypropylene fibers. It is destined to become a prime candidate for rug backing. Today, most of the tufted carpets use jute backing, which, as I think you know, is imported from India and Pakistan. The availability of jute is uncertain and its price fluctuates wildly. Probably you know that tufted carpets are made today by putting pile fabrics into jute fabrics with needles which penetrate the backing. And when jute is used, the needles cut through the jute fibers, and if too many tufts per inch are put in the carpet, the jute backing is seriously weakened. Furthermore, jute changes dimensions as the humidity of the room changes, leading to wrinkling of the carpeting. By using a polypropylene fiber which does not change in dimension with changes in humidity, the dimensional stability problem is avoided.

Another spunbonded material on which we are working is called Tyvek spunbonded olefin. This is another new structure on which we have a basic patent position. Tyvek materials provide tremendous covering power, extreme toughness, and a smooth surface that provides excellent printability.

## Bright Future Looms

Here are three examples of the utility of Tyvek. This sample shows its use in wrapping a metal trim that General Motors ships to its assembly plants. The trim is currently packaged by wrapping first with bulky paperboard and then with a piece of paper. Only one thin sheet of Tyvek is required. Even bolts and nuts on the metal piece do not penetrate the Tyvek. Its smooth surface permits instructions to be printed directly on the Tyvek.

Another use is in wall covering. Here's a sample of wall covering that has been printed and then embossed to give a good three-dimensional pattern. Another good property is its ability to be removed from the wall by pulling off the whole sheet in one piece.

Here's an example of the use of Tyvek in bookbinding. It is low-cost, readily coated, very tough, and can be printed in multicolors.

Where Tyvek will ultimately be used we are not sure. It may have some application in disposable garments. Today, disposable swim trunks of Tyvek are being sold at a number of motels around the country for $1 a pair.

Let me sum up my comments on spunbonded materials. They provide performance and economic benefits that may prove extremely beneficial in applications where unusually high covering power, high tear strength, and a desirable behavior in coating and impregnating are important. They should have a bright future.

Now let's switch from the fiber business to some other activities. Recently we have launched an effort to develop a line of new building products for sale to the large residential housing business.

I just want to mention one of these products because it is related to the panel subject today. This is a nylon shutter. Now you may ask how can we expect to sell this shutter or how can you afford to buy this shutter when it's made from material like nylon instead of wood. The answer is that by developing a special process for producing the shutters which circumvents most of the steps required in building the wood shutter, it has been possible to come up with a superior product that can be installed on the home for approximately the same price as a good quality wood shutter, in spite of the fact that wood sells for about 2 cents per pound and nylon polymer sells for 30 to 40 times as much.

This is another example of how advancing technology can, by integrating production from raw materials to finished products, markedly change the economics that apply to old and time-tested ways of doing things.

## Corfam Comes to Heel

Now let's take a look at Du Pont's commercialization of a new scientific concept--Corfam poromeric material for the $400 million American shoe-upper market. Here is a roll of Corfam. For several decades Du Pont scientists have been trying to develop a material that has the two key properties of leather--breathability and durability. It proved to be a very difficult assignment, and markedly increased our appreciation of the accomplishments of the cow. In the mid-forties, five different groups were working on different approaches to a leather-like product. It wasn't until 1955 that one of these efforts was successful in the laboratory. By 1958, after 20 years of work, it still took a week to produce a 50-foot roll at an astronomical cost.

The first real commercial plant started operation in the fall of 1964. In that year a million pairs of shoes made of Corfam were sold. Now our main problem is to produce enough to satisfy the market.

I thought you might not know what I mean when I refer to a poromeric material, so I brought along the official definition for it. It is a microporous, impermeable, coriaceous sheet material comprising a urethane polymer reinforced with polyester fibers. I hope that helps you.

In case you haven't seen any products of Corfam, you may be interested in looking at this exhibit after the meeting.

Perhaps the most advantageous qualities of Corfam are its ease of maintenance and its long life. These properties are well illustrated by these two shoes worn in one of the early tests of Corfam, carried out in an orphanage. The boys were given one shoe of leather upper and the other of Corfam upper. When our technical men came back after a few months to inspect the shoes, they were surprised to find no difference between the right and left shoes worn by the boys, but a marked difference from boy to boy. This flabbergasted our technical people until they realized that the boys had outsmarted them. There had been such a big change in the appearance of the surface of the shoes that the boys changed shoes to get them to match. Here is a pair of the shoes used in the test. Although the shoes are practically falling apart, the upper made from Corfam is still in good shape. From this test we became convinced that we had a good product for the shoe-upper business.

## New Ventures Launched

Cows, like human beings, vary in the thickness and quality of their hides. Corfam, on the other hand, is produced in rolls of uniform thickness and quality. This provides major economies in shoe manufacturing, permitting, for example, up to 16 thicknesses of Corfam to be automatically cut at one time. We have no illusions that Corfam poromeric material will make leather obsolete. Corfam can make only a relatively minor impact on the three billion square feet of shoe-upper material used yearly by the free world. But the world's human population, as we hear repeatedly, is rising more rapidly than the animal population from which leather comes. So the greatest significance of Corfam may be as a safeguard against a leather shortage.

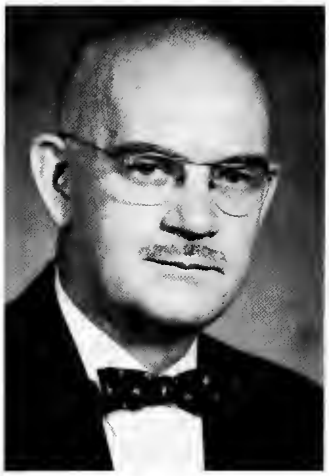
That completes my remarks about some of the Du Pont developments of significance to agribusiness. Now let me conclude with some brief comments about the management of business.

As you well know, today's farmer is a manager in every sense of the word. He must learn management skills to compete effectively. As I was preparing for this talk I couldn't help reflecting on the similarity between the assignment of the manager in agribusiness and that of the manager in the industrial world where I work. Because of this similarity, I thought it might be helpful to tell you of a management experiment we are conducting in the organization I head in the Du Pont Company. My assignment is to launch new business ventures outside the current commercial interests of the Du Pont Company. Our company's history tells us that our future success is, to a major extent, dependent on the launching of new ventures. Almost certainly the future success of agribusiness is also dependent upon the launching of new ventures. The experiment of which I speak involves the complete separation of the organization for launching a new business from organizations running existing businesses. It enhances the probability of success by coupling the talents and accomplishments of the laboratory with the wants and aspirations of the marketplace. It involves keeping the new venture in a single organization from its inception, or from its selection for exploitation to its commercialization, thus avoiding the sometimes fatal N.I.H. factor, or "not invented here" factor, which often arises when a new development is passed from one organization to another.

## Agribusiness Does Likewise

Now I am neither so naive nor so presumptuous as to think that the organizational approach of which I speak is unique or that it's applicable to all situations. I do think however that in the area where I am assigned in the Du Pont Company, it is a good approach. What I especially want to emphasize, however, is that we should organize to do the job at hand--not assign a new job to an old organization which was set up for quite a different purpose. I realize that there are some good examples of entrepreneurs in agribusiness doing about what I have recommended. But I ask you, could this approach of organizing specifically and exclusively to launch a new business be used more extensively and effectively in agribusiness?

I have tried here today to review some factors in the research and development area which I believe will have a large impact on agribusiness, and through specific examples of Du Pont Company developments, to illustrate some trends of the recent past which may well help us to see into the future--to become architects of change rather than victims of change. The objective of all of us in business--agribusiness or otherwise--is to make a satisfactory profit by satisfying a need or want of our fellowman for a price he is willing to pay. With continuing freedom of enterprise in our land, the opportunities for doing this are great. It is up to each of us to have the vision, the dedication, and the industry to capitalize on the opportunities.



# PETROLEUM AND OTHER CHEMICAL SOURCES OF FOOD

Samuel R. Hoover
Assistant Deputy Administrator
Nutrition, Consumer & Industrial Use Research
Agricultural Research Service
U. S. Department of Agriculture

When we talk about feeding people, if we mean to furnish the protein and caloric needs, we are talking about substantial quantities. Each of us eats nearly 30 pounds of food a week--10 pounds of vegetables and fruit, 8 pounds of milk and dairy products, 4 pounds of meat, 3 pounds of cereal products, 1 pound of eggs, 1 pound of fat, and 1 1/2 pounds of sugar.

Let me put it another way. If we take only the essential protein, fat, and carbohydrates to make us run, put them together in a pill, you get this--a pill about the size of a pound of butter. Let's discuss this pill for a few minutes.

The human body is a combustion engine that does work, and it repairs itself daily. For the moment, let us ignore the need for vitamins, for minerals, for roughage, and just consider the requirements of this engine for fuel and repair.

## Adult Caloric Supply Varies

The requirement decreases with age. It increases with size of the person, and with the physical activity of the individual. A reasonable value for a 45-year-old, 154-pound man, leading a moderately active life, is 3,000 calories per day; for a woman of the same age and activity, weighing 128 pounds, it is 2,200 calories per day. A rough value of 2,600 calories is often taken for a desirable adult caloric supply.

We burn proteins, carbohydrates, and fats; these are the fuels of our bodies. We each get the same amount of energy out of each gram of protein and carbohydrate we burn--4.1 calories per gram--while fats give twice as much energy when burned--9.5 calories per gram.

Let us then construct a reasonable diet to provide about 2,600 calories a day. It will consist of a definite amount of each fuel (A), which when multiplied by the constant (B) gives the total calories from this source (C):

|  | A<br>grams | B<br>calories per gram | C<br>calories |
|---|---|---|---|
| Protein | 100 | 4.1 | 410 |
| Carbohydrate | 250 | 4.1 | 1025 |
| Fat | 120 | 9.5 | 1140 |
|  | 470 |  | 2575 |

A pound is 454 grams, so the "pill" will weigh slightly over one pound! It will be about the size of a pint of milk.

If we desire less fat in the diet, the weight of the pill will go up. One quite low in fat will weigh about 600 grams, about 1-1/3 pounds. So when we take that pill it will be a large one.

## Challenge to Chemical Industry

The point I want to make is that substantial amounts of material are needed to feed us. These are produced by agriculture today for from 3 to 6 cents per pound in the cereals, oilseeds, and legumes. From here you can pay more, depending on your desires and pocket, up to $2.69 a pound for filet mignon. Last week, shad roe was selling for $4.25 per pound in the supermarket in Washington.

This is the challenge facing the fermentation and synthetic organic chemical industry in producing basic foodstuffs. Vitamins, color, and flavor are different stories, which I will discuss later. The problem is--if the basic caloric needs in requirements for proteins, fats, and vitamins are met--how can it be done most efficiently? (Parenthetically, I want to call your attention to an article entitled *Food for the World*, by Howard W. Mattson, published in International Science and Technology, December 1965. In my opinion it is the best analysis of the food needs of the world and the alternatives for meeting them.)

## Protein from Petroleum

Research and development on the production of yeast or bacterial cells as a source of feed or food protein from petroleum is being actively carried on in industry and in universities in this country and abroad. Naturally, much of the work is being done in the petroleum industry and is not very fully disclosed in the scientific literature. The first published announcement was of research of the Société Francaise des Petroles BP, a French affiliate of the British Petroleum Company. (European Chem. News 4(78), 32, July 12, 1963. A. Champagnat - Bulletin de l'Académie Nationale de Médicine, 147, No. 9 - 10, 1963, p. 182-186.)

It was later reported that this process was in operation in a 50-ton-per-day pilot plant at Lavera, France, producing materials for animal feeding studies.

The most informative report of industrial research was the presentation of the joint research of Esso Research and Engineering Company and Nestle Alementana SA, by J. G. McNab and Louis R. Rey at the December meeting of the AAAS. A relatively full review of this paper was published in C&EN, January 9, 1967, p. 46. The next slide shows the process schematically. This group utilizes a highly purified substrate, thus eliminating the need for extensive purification of the product obtained. Hydrocarbons containing from one carbon atom to 30 were studied. A fraction containing $C_{13}$ to $C_{19}$ was selected, which contains 99 per cent of normal straight-chain hydrocarbons. Yeasts have a higher lysine content and grow at lower pH, where contamination is less likely to occur. They are also larger than bacteria, thus simplifying recovery.

## Cells Are Harvested

The bacteria evaluated thus far have a higher protein content and a greater growth rate, and require a simpler medium than yeast.

In a continuous fermentation, the average residence time of the substrate and cells is one to four hours. The cells are harvested by centrifugation, and washed to remove adhering growth medium and reduce the salt content. The cells then undergo a heat treatment designed to destroy viable organisms. The treatment, which must be carefully controlled, also improves the nutritive value of the product in digestibility and availability of nutrients. Finally, the cells are dried to produce the product, which is called SCP (single-cell protein).

SCP is rich in essential amino acids and the B vitamins. The content naturally depends on the particular organism and the conditions used. Because the numerous variables are not yet completely tied down, cost estimates are necessarily not definite. A value of 35 cents per pound of a pure protein was given. This is roughly equivalent to that of torula yeast produced from by-product sugars of the paper industry. Food grade torula is currently 17 cents per pound, and contains 48 per cent protein or 36 cents per pound on a pure-protein basis.

## Economic Feasibility

My review of this field was greatly facilitated by the report Growth of Microbial Cells on Hydrocarbons, with a subtitle Microbial protein feeds from hydrocarbons could be abundant if technological problems were solved, by Marvin J. Johnson, Science, 155, p. 1515, March 24, 1967. Dr. Johnson reviews the work in his laboratory at the University of Wisconsin and other published work. He presents evidence that a mixed culture of two different strains of Candida is more effective than a single strain, and discusses the problems remaining. I will quote portions of his concluding discussion of economic feasibility. It must be noted that he restricts his comments to the production of animal feeds, not human food.

"The scanty work done thus far on production of microbial cells from hydrocarbons suffices to demonstrate the scientific feasibility of producing useful animal feeds, and to make clear some of the economic difficulties that must be overcome if such feeds are to become practical.... It may appear that production of microbial cells from hydrocarbons would now be economically feasible, given the savings attainable by very large-scale production; but there are a number of difficulties. The most serious is the problem of oxygen transfer. When one gram of microbial cells are grown on carbohydrate, one gram or less of oxygen is used. Growth of bacteria on alkanes requires about two grams of oxygen per gram of cells produced. When cells are grown on methane, with yields currently obtained, about five grams of oxygen are required per gram of cell.... By use of methane, the cheapest hydrocarbon, raw material costs are reduced but fermentation costs are increased because of higher requirements for oxygen." He concludes, "Consideration of the economic factors involved in the production of protein from hydrocarbons makes it clear that research is needed on yield improvement, on the isolation of cultures of the highest possible nutritive value, and on comparison of various practical hydrocarbon sources. Engineering research is needed on methods for harvesting bacterial cells, and on the design of fermentors of high capacity to transfer oxygen."

## Other Petroleum Fermentations

It is possible to produce fatty acids by fermentation of petroleum, as well as a range of alcohols and esters that could serve as a source of human food. There is some industrial research on these problems, probably appreciably more than I am aware of.

Research groups at State University of Iowa, University of Texas, and Pennsylvania State University have reported basic research studies on the pathways of these oxidations and in some cases on yields and nutrient requirements. It has been reported that scientists at the University of London, working under a British Petroleum grant, have determined the conditions of oxidation of hydrocarbons to fatty acids by a strain of Pseudomonas.

Similar work is being carried on at Centre National de la Recherche Scientifique, Marseilles, France. I do not know of pilot plant work on these processes but I have no doubt they are technically feasible.

Economic feasibility will depend on the cost in competition with edible animal fat and vegetable oils, which at present sell in the range of 8 cents a pound to 13 cents a pound. (A competing source of edible fats in the future could be the non-edible animal fats, of which about 5 billion pounds are produced annually in the United States. These are not legally a food grade product, and some of the lower grades would be difficult to process to a satisfactory food product. However, application of modern oil and fat technology could convert a high percentage of these inedible fats to an edible product if they were needed. Such processes have been used from time to time in other countries to manufacture margarine, etc.)

## Chemical Synthesis

The term synthetic foods has been used in many different ways. For the purpose of this discussion, I believe synthetic sources of foods should be restricted to products made from non-food sources. Thus, for example, mono- and diglycerides are the largest volume of chemical additives used in our processed-food industry, 120 million pounds a year, with a market price of $30 million. These are produced by partial hydrolysis of natural fats and do not extend our food supplies to new sources. In the restricted definition I have chosen, they are not synthetic food ingredients.

I am also omitting discussion of flavors for two reasons. First, despite their obvious value, the quantities used are small, and they do not contribute significantly to our metabolic needs. Secondly, Dr. Allen Day was on the program yesterday to give a far more sophisticated treatment to the subject than I could.

## Synthetic Amino Acids

An especial role as a food supplement can be served by synthetic amino acids. Proteins vary in amino acid content, and in controlled feeding experiments with animals, primarily the ever-useful white rat, it has been repeatedly demonstrated that lysine is a limiting nutrient on a diet based on wheat. Therefore, there is much current interest in supplementing cereal diets with lysine. Not much lysine is required (0.1%) to improve the protein efficiency of wheat from about 1.1 - 1.3 to 1.8 - 1.9. This represents a significant improvement in the biological value (the protein efficiency ratio) of wheat protein in the diet of experimental animals.

Lysine would cost $1.25 to $1.50 a pound in large-scale commercial production today. It can be simply calculated that the desired improvement in protein value, on a predominantly wheat-based diet, would cost about $5 a ton. This figure covers the cost of lysine and the cost of the addition and monitoring system.

We have some evidence that young children wouldbenefit from lysine supplementation. There is little evidence that children past the age of 5 and adults would benefit from supplementation of their diet with lysine.

## FAO Conclusion

Nutritionists of FAO have looked at the problem of amino acid supplementation around the world and have concluded that sulfur-containing amino acids--methionine and cysteine--are in many cases the limiting amino acids in protein nutrition. Synthetic methionine ($1.05/lb.) is added (1 lb./ton) to commercial poultry feeds. Today there is no economically satisfactory route to the synthesis of threonine.

An additional important factor is apparent in many recent results of experiments in protein nutrition of humans. The so-called non-essential amino acids --those that can be synthesized in the body--make up a very large part of body protein. Their synthesis requires a source of the ammonium ion, $NH_4^+$, for transamination to carbon chains, to make these non-essential amino acids. It is a reasonable possibility that urea, glycine (the simplest amino acid), or ammonium salts such as diammonium citrate or phosphate can become of major importance in the synthetic chemical supplementation of proteins of cereals in the coming years.

## Vitamins--Food or Drug?

Are they a food or a drug? Their usefulness in nutrition is not a matter of question. The quantities used, however, are small enough that chemical synthesis and purification is economic. The discussion so far has been in terms of pounds. A gram is 1/454th of a pound. Vitamins are required in milligram ($10^{-3}$) and microgram ($10^{-6}$) quantities. The next slide shows you the number of days' supply that one gram of some of the important vitamins will furnish. They vary from 14 days for ascorbic acid, Vitamin C, to 200,000 days' needs supplied by one gram of Vitamin $B_{12}$.

## Chemical Sweeteners

In discussing these compounds, primarily saccharin and the cyclamates, I am violating one of the ground rules that I set up a few paragraphs ago. These are non-food foods. They furnish no energy, only sweetness. I introduce them because other papers in this conference deal with food substitution.

Here we have a chemical competition with farm products that has a major market for the overfed American. Saccharin is 300 times as sweet as sugar. The cyclamates are 30 times as sweet. Today, they are commonly compounded together with 10 parts of cyclamate and one part of saccharin, giving a product roughly 60 times as sweet as sugar and with less of the bitter taste and aftertaste detected by some people when they consume one of the artificial sweeteners.

The primary market for these products is soft drinks. The low-calorie drinks are sweetened at a cost equivalent to roughly the price of sugar at one cent per pound. It is obvious that the soft drink companies would just as soon use synthetic sweeteners as sugar if the public demands them.

The use of synthetic sweeteners has grown from four per cent of the soft-drink market in 1962 to an estimated 25 per cent this year. How far this almost straight-line increase will go is difficult to guess. There is no question that it will continue to rise.

The extent to which these sweeteners have substituted for sugar in the soft-drink market, or have expanded the market by creating a new market among overweight persons and dieters, is not easy to determine. In fact, no one has, as far as I know, attempted to make a solid estimate. In my family it has been primarily an extension of soft-drink markets.

### High Energy Foods

At least partially stimulated by needs of the military services and the space program, a possible new set of synthetic foods has been discovered. These were not made in an attempt to simulate existing foodstuffs from agriculture. They are variously called high-energy foods and energy-dense compounds. These are synthetic compounds that have large-scale industrial markets.

The next slide compares the structure of two of these, propylene glycol and 1,3 butanediol, with ethanol, a well-known source of metabolic energy but one with specific physiological properties that make it less than completely satisfactory as a food. As you see, the structures are quite similar. These compounds are metabolized in normal fashion by experimental animals, and they lack the physiological activities of alcohol as far as I know. (High Energy Diets from Synthetic Sources by H. A. Dymsza and G. S. Stoewsand, published in Activities Report, Vol. 18, No. 2, p. 119, 1966.)

The current price of propylene glycol is 14 1/2 cents per pound and 1,3-butanediol is 18 cents per pound. These compounds have an energy equivalent of six calories per gram, intermediate between that of carbohydrates and fats. Calculated on a calorie equivalent, which is the most reasonable way, the prices cited would be 21-3/4 and 27 cents, respectively.

There are straight-chain alcohols of chain length 16 to 20 produced by chemical synthesis from petroleum. These can readily be converted to fats, probably at a price of 20 to 25 cents per pound.

## CONCLUSION

If the price of farm products derived from crops were doubled, they would still be cheaper than synthetic sources for the production of protein, carbohydrate, and fat. The implications of this fact are great, for no one has calculated the effect on agricultural productivity of wheat at $4 a bushel, corn at $3 a bushel, and soybeans at $5 a bushel. Yet at these prices the fermentative and synthetic routes could not compete.

Also, no one has calculated the effect of such increases on the cost of milk, meat, and eggs. Feed costs are major factors in their production, as is obvious, but, with the increasing efficiency of animal production and processing, the effect of these costs on retail market prices of animal products may well be reasonable.

I am convinced that the fermentative and chemical synthetic route to our bread, fruit, vegetables, eggs, milk, and steaks has a long hard road ahead.

# NUTRITIONAL EVALUATION OF NEW FOODS

Mary A. Morrison
Professor of Food and Nutrition
New York State College of Home Economics
Cornell University

Nutritional surveys in this country, as opposed to other areas of the world, have indicated that the general population is well fed. Very few indications of gross deficiencies in nutrients, which lead to clinical symptoms, have been observed in the several nutritional surveys that have been conducted. In fact, overnutrition with respect to caloric intake is as much a hazard here as undernutrition.

This situation is in direct contrast to that in many other areas in the world, where gross nutritional deficiencies are observed. A segment of the population that is particularly affected in these areas is the preschool child who has a high protein requirement. Protein-calorie malnutrition associated with deficiencies of other nutrients is widespread. Thus, there is a requirement of an available source of protein of good biological value which could readily be produced or obtained in the areas in question. From the economic and agricultural possibilities involved, the protein will need to be obtained from other than animal sources. Thus, a situation exists in which certain areas of the world require both increased availability of calories and protein, and other areas need a method of reducing caloric intake.

## Evaluation of New Foods

The topic of the evaluation of new foods should be considered in relation to the normal dietary pattern of the individual involved. If foods are planned for segments of the population where choices of food are limited, then particular attention must be paid to how these foods will meet the needs of the group being considered. Groups that are particularly susceptible are infants, persons on restricted diets, preschool children in certain developing areas of the world. Thus, for example, substitutes for milk in the diet should include the important nutrients in milk. If foods are planned to replace or substitute for other foods, then the contribution to nutrition in general is important.

In the past, gross nutritional defects have showed up as a result of two sets of circumstances. One of these occurred when the variety of the available food supply was limited. In this connection, one might cite the evidence with respect to scurvy, caused by a lack of vitamin C, which was particularly evident in long sea voyages where there was a lack of fresh food, or the occurrence of pellagra in the Southern United States, when diet was limited in variety, and a main staple food was corn. The other set of circumstances developed from the processing of various foods, and was particularly noticeable where food choices were restricted. In this instance we might refer to loss of B vitamins in polished rice, leading to a prevalence of beriberi in the Far East. More recently, the loss of vitamin $B_6$ destroyed in the processing of an infant food, has caused serious difficulties.

These deficiencies were evident in populations where there was no wide selection of available food, and they have been largely corrected by either increasing the number of sources of food in an area, by fortification of common products with deficient nutrients, or by more rigid control of processing procedures.

## Problems in Selection

The nutrient that is probably most limiting in the diets of people in the world in general, and that is also an important component of prestige foods in many areas, is protein. We have known about proteins in general for a long time and have, in the past, classified them as proteins of high biological value, which included mostly those from animal sources such as meat, eggs, and fish, and those of lower biological value, as in cereals, that is, plant proteins. The factors that control the value of protein in the diet are the amounts of the essential amino acids they contain and the amount of total protein in a foodstuff. Thus, a food may have a protein of moderate biological value but contain only a small amount of the protein, i.e. rice contains 6-7 per cent of protein, wheat 12-14 per cent, but ingestion of larger amounts would supply the required amino acids to some segments of the population. Although the essential amino acids are all equally important in the diet, those most likely to be limiting in the diets of human populations are lysine, methionine, threonine, and tryptophan. Provision of the essential amino acids and sufficient nitrogen for the individual from combinations of food sources are as acceptable nutritionally as a single source.

Since plant proteins are generally limiting in one or more essential amino acid, the percentage of protein in the plant also is often low, and animal protein cannot be supplied in sufficient amounts for world needs, alternative sources of protein have been investigated and various combinations suggested for use in human diets. Sources such as oil meal cakes from soy, peanut, cottonseed, protein from fish products, algae, and microorganisms grown on petroleum have been suggested.

To obtain many of these proteins, certain purification steps and extraction methods have been necessary. Protein from soy and cottonseed will have to be obtained from residues after the oil has been expressed. Some proteins will have to be separated from cellulose materials or extracted with various solvents, as with fish protein. In all these cases, there is danger of alteration of the amino acid content of the protein, due to processing, with the destruction of some amino acids. Adequate control is essential to ensure duplication of high quality products.

## Amino Acids in New Foods

In considering new products that will be used as alternatives to existing products, the amino acid content of the protein and its potential for maintaining nitrogen balance is important. It would appear to be simple in this day and age to ensure that the protein was at least equivalent to, or better than, the food it will replace. We have available at present a source of crystalline amino acids which could be added to supply any lack that might be found, or selection of various types of available proteins could supply both the required pattern of amino acids and an adequate concentration of protein in the food mixture.

The combination of food proteins used must also be such that they are acceptable to the population for which they are designed, in addition to providing the amino acid composition desired. Foods acceptable to one culture may be quite unacceptable to another group. Before supplementation of proteins can be carried out, a knowledge of the amino acid content of the protein and the amino acid requirement of the human population for whom the food is designed is necessary.

Although tables of the amino acid composition of varieties of foods are readily available, the methods for determining the composition of these proteins present a serious limitation. Procedures to determine amino acid composition require some method of hydrolyzing the protein into constituent amino acids, a procedure that will ensure complete breakdown of the protein (since not all peptide bonds are broken with the same ease), and one in which amino acids will not be destroyed in the process. A completely satisfactory procedure has not yet been accomplished. The methods largely used now require a long heating procedure in acid. Some of the amino acids most difficult to determine are methionine and cystine, which are readily oxidized, tryptophan which is destroyed by acid hydrolysis, and threonine which is destroyed in long heating. If we are to use in human foods protein materials that have been subjected to heat treatment, extraction, and various other procedures in which alterations in the amino acid content can occur, a knowledge of the effect on the individual amino acids is important. Supplementation cannot be done intelligently without a knowledge of the basic content of amino acids. The hydrolytic step involved in determining amino acid content is perhaps the most critical one, and one on which investigation is needed.

## A Rapid Assay Method Sought

A rapid-assay method is needed of the biological value of the protein, at least to measure possible changes in the biological value that might have resulted from treatment of the protein in processing. Various attempts to provide a rapid assay have been suggested, but all have certain limitations. Among these has been use of bacteria, Streptococcus zymogenes, which require the protein to be partially broken down by an enzyme pepsin before assay, a protozoan, Tetrahymena pyriformis W, which utilizes intact protein, and a chemical method for available lysine. These methods are used to monitor changes in amino acid content, caused by various processing treatments of the protein, and are important to maintain quality control of the product.

Knowledge of the requirements of the individual is needed, if combinations of protein materials to provide the essential amino acids are to be efficient. Unless one plans to duplicate an already existing natural protein, the supplementation should be done to provide a material that will be most beneficial to the population. In this one assumes that knowledge of amino acids and protein requirements is available. Actually a great many investigations have been made, and certain minimum requirements have been established, but there is still a lack of information on the range of intakes of amino acids where good utilization will take place with no adverse effects. In animal studies, it has been shown that excessive intakes of some of the essential amino acids can affect the utilization of others. Little evidence is at present available for human populations, although some work with children indicates that supplementation of amino acids must be done with care or a less effective combination can result.

Before use in human diets, the combination of proteins or new protein sources must be tested for digestibility and the ability to maintain growth or nitrogen balance. The amino acids in a protein are not always completely available to the animal, and this availability varies from protein to protein. Actual metabolic tests are thus necessary with a new protein source. It is, of course, essential that the products to be used are in a form that is acceptable for the segment of the population for which it is designed.

## Other Factors to Consider

New food products are going to be continually placed on the market in competition with or as replacement of foods with which we are familiar. If we take a product that is to supply an alternative source of protein in the diet, as for example a processed soybean in form of ham, hamburger, etc., factors in addition to the protein quality and quantity must be considered. Minerals and vitamins are normally found in conjunction with the protein food. In normal diets, there is at present no need for any therapeutic preparations of vitamins and minerals. A properly selected diet can contribute these without dependence on outside preparations.

If a preparation made from purified ingredients is to be used, consideration of the fringe benefits of the food it replaces is to be recommended. Thus, a meat product normally provides for B vitamins, as thiamine, riboflavin, and niacin, as well as the mineral iron. The requirements of the individual for these nutrients have been investigated and a desirable level of intake suggested. In addition to the above nutrients, however, meat contains other minerals referred to as trace minerals such as magnesium, manganese, zinc, etc. At present, there are no specified requirements for these minerals in human dietaries. Part of the reason that no requirements have been specified for these minerals is that they are found distributed in normal foods ingested by populations, and also that no areas of gross deficiencies have been found. Although exact amounts have not been specified, these minerals are required in animal nutrition, and thus probably in human nutrition. At present, only small amounts of the minerals are required, and there is evidence that large amounts could be toxic. In addition, the amount of one mineral in the diet appears to affect the amount of another which is required. In other words, there are important interrelationships among minerals. Since a good "balance" of minerals for human dietaries is not yet known in suffficient detail, one cannot indiscriminately add minerals to all foods. Vitamin D, which is normally added to milk, was at one time also added to various infant cereals. It was found in this case that there was a danger of too much being ingested by an infant if all foods used were fortified with this vitamin.

## Random Addition Not Sound

Although the number of food analogs in the market is limited at present, with the anticipated increased distribution in the future a food should not be considered as an isolated case in considering the effect on the nutrition of the population. In using a replacement for a well-known food, in addition to protein, consideration must be given to the minerals and vitamins associated with it. In this way, one can readily replace one product with another. This has been done in adding vitamins to white flour or to rice or vitamin A to margarine. However, at this time, it would be impossible and undesirable to replace all of the nutrients in a food. Although the various nutrients themselves may be readily available, sufficient knowledge of requirements of individuals is not yet available. Since the requirements for some nutrients may be affected by the amount of another nutrient present, random addition of minerals and vitamins is not nutritionally sound.

When a food product is prepared for a segment of the population where a variety of food intakes is restricted, particular attention to the nutritional composition of the food is important. I refer particularly to foods prepared for infants, or possibly for groups such as the elderly or hospitalized patients. The cereal products on the market for young children vary widely in nutritive value. Iron, which is important in these products, is needed by infants, yet there is a twofold difference in the content of various products. The same situation is true of B vitamins and proteins. Thus, if an intelligent decision is to be made, the consumer must read each label carefully, and with the variety of products on the market this becomes increasingly difficult.

## Caloric Content of Foods

An area in which the nutritional value of the diet has been altered by introduction of modified foods includes instances in which the caloric content of the diet has been reduced either by the removal of the fat component or by the substitution of artificial sweeteners such as saccharin or one of the cyclamates.

These changes particularly affect caloric content, but the effect on some other nutrients should be considered.

One important area in which the fat content has been removed is in skim milk and skim milk products. Skim milk is now readily available on the market in both the liquid and dry form. Since skimmed milk lacks the fat component, it also lacks fat-soluble vitamins, particularly vitamin A. Also many years ago, fluid milk was selected as an appropriate food material to which vitamin D could be added. Vitamin D is still added but many dairies have apparently eliminated the vitamin D from the milk, although the need in the diet still exists. Skim milk needs to have a source of vitamins A and D if it is to be used as replacement for whole milk. One can adjust for energy content of the diet, but not readily for the lack of these vitamins. For vitamin D, there is no natural dietary substitute which contains the material and it is especially necessary for infants and children. It is perhaps the one vitamin which cannot be supplied normally in food products. If an alternative source of fat is used with skim milk or skimmed milk products (as in filled milk and filled milk products), the nutritional value in the diet will be lower than that of a comparable milk product unless allowance is made for the fat-soluble vitamin content.

The use of artificial sweeteners is largely in foods that have provided extra unneeded calories in the diet, and such substitution is really a method by which one can have the pleasures of life without consequences. Significant amounts of these materials are now being used in various foods. At present a high percentage is used in carbonated beverages. Again, while all these artificial sweeteners, as sucaryl and saccharin, must pass Federal Food and Drug laws, the excessive intake of these foods in a population has not really been widely studied, although extensive animal studies have been conducted. Studies on continued intake in individuals over periods of time have been done, but more studies will be needed with the continued increased use of these artificial sweeteners. Original studies did not show adverse effects.

## Alteration in Fat Content

Alteration of the fat component of many foods has also been widely practiced in recent years, but it is sometimes difficult to know the exact composition of the fat in the food. Vegetable oils have been used in filled milks, margarines, vegetable fat ice cream, frozen desserts, and other products. The widespread publicity on value of polyunsaturated fat--particularly linoleic acid and arachidonic acid in reducing blood cholesterol, and thus perhaps lessening the risk of atherosclerosis and heart disease--has led to use of various vegetable oils in place of other types of fat. In addition, the cost of the various types of fats has been instrumental in the change in use. While it is true that saturated fats are found in abundance in many animal products, and that the quantity of polyunsaturated fats is low, the exact amount of each of the fatty acids in the diet of humans to produce maximal benefits to the individual are not yet known. Margarines are produced from a large variety of vegetable fats. These may include such vegetable oils as corn, soybean, and cottonseed. These oils must be partially hydrogenated or mixed with some more saturated fat to produce a product that can be spread. Unfortunately, the labels on these products frequently state that they are made of "partially hydrogenated oils"; thus the exact amount of the saturated fats in the product cannot be determined from the label. If these products contain partially hydrogenated oil, the exact amount of the polyunsaturated fatty acids is not known because, when it is hydrogenated, some of the bonds become saturated. In general, the acids with the most double bonds, i.e. highly unsaturated acids, are hydrogenated more readily than the less unsaturated acids. If part of the oil is hydrogenated, and part untreated, a different situation exists, since at least minimum amounts of unsaturated acids could be determined.

While it is true that linoleic acid (a polyunsaturated acid) does reduce blood cholesterol, and that values have been found higher with saturated fats, this is only part of the picture. There is a complex relationship between cholesterol levels in the blood and the content of the dietary lipids. There is not necessarily a direct relationship between cholesterol levels and atherosclerosis and heart disease. Other factors, such as the level of triglyceride in the blood, may also be important. This latter fat component in the blood appears to be related to the amount and type of carbohydrate, with higher carbohydrate content being associated with higher triglyceride levels.

Thus, at present we have a situation in which the knowledge of extent of the role of the saturated and unsaturated acids in relation to atherosclerosis and heart disease is constantly changing, and in evaluating products, the change in knowledge must be taken into consideration. In new products, a differential use of these fatty acids is possible, but the use in products should be modified with existing nutritional knowledge. A reduction in fat intake may result in an increased intake of carbohydrate, which may be in a refined form. The significance of this change is not yet known.

One further point with respect to unsaturated fatty acids might be mentioned. Widespread use of large amounts of these acids is recent. Since this trend differs from that of normal diet of a few years ago, the effect on various other nutrients is not yet known. Investigators have suggested that the need for vitamin E in the human may increase with an increase in intake of unsaturated fats, although at present there is no requirement for vitamin E in the diet. Vitamin E is present in the normal diet.

## General Considerations

The nutritional value of new foods in American diets must be considered in relation to other components of the diet. Up to this time, the nutrition of the population has been generally good, although the wide occurrence of overweight and heart disease is a matter of concern. The former is due to an excess of food, but the latter probably has multiple causes.

If food products are altered by reducing the fat component, the total energy required in the diet must come from another source, such as protein or carbohydrate. Of these two components, the easier form to supply would be the carbohydrate. Although certain individuals should reduce their caloric intake, this reduction is not needed by the entire population. An adequate caloric intake, particularly in children and adolescents, is essential for good utilization of protein and for growth. In a family situation, reduction of fat intake or use of artificial sweeteners, and thus a reduction of total calories, may be ideal for certain adults but detrimental to children.

In summary, new foods and new food products will probably be considered as substitutes for, or alternatives to, present foods. The nutritional value of foods that replace staples in the diet should be carefully evaluated. If foods are to replace meats, consideration should be given to the provision of B vitamins and other minerals in the diet. Foods that can be used as substitutes for milk and cheese should be evaluated with respect to calcium and B vitamins, particularly riboflavin. If any of these foods are to be used for segments of the population that have a restricted variety of foods in the diet, the provision of adequate minerals and vitamins may become a matter of concern. With the wide variety of products now on the market and the number of products projected for markets in the future, some consideration must be given to the total availability of the nutrients. In foods such as the textured soy protein fiber products, many variations in content of various nutrients are possible. Effective use of foods and education for use of new foods will be impossible if some consistency of nutrients is not maintained.

# ECONOMIC AND POLITICAL IMPLICATIONS

Kenneth L. Robinson
Professor of Agricultural Economics
New York State College of Agriculture
Cornell University

My assignment this morning is to try to assess the economic and political impact of developments relating to new foods, flavors and analogs. The hazards of forecasting are well known, and the risks rise as the time period over which forecasts are to be made lengthens. For this reason, I shall confine my comments to what is likely to occur over the next 10 to 15 years.

My own conclusion, based on what information I have been able to assemble from other sources as well as from the talks presented here, is that the immediate impact of these developments on agriculture in the Northeast is likely to be limited. At some future date, the character of agricultural production in the Northeast conceivably could be altered quite radically by developments now coming out of public and private research laboratories, but sharp departures from recent trends are unlikely during at least the next 10 to 15 years.

## Impact on Firms Greater

This does not mean that agriculture will remain static. One can expect recent trends in the development and use of substitute products to persist, and perhaps even to accelerate, but this is likely to have only a modest effect on producers of fluid milk, fruits, vegetables, and eggs. However, the mix or combination of inputs used to produce these commodities, including the ingredients used in animal feed, may change significantly. The form in which some of these products are consumed also may change because of further processing or by mixing or adding ingredients so as to make the final product more convenient or acceptable to the consumer. This suggests that the short-run impact of new product development is likely to be greater on firms involved in supplying farm inputs or in processing and handling existing raw products than on farmers themselves.

My conclusion with respect to the relatively limited impact of the new developments discussed at this conference on agricultural production in the

Northeast, at least during the next 10 to 15 years, is based on four factors:

1) The products that account for most of the income of farmers in the Northeast are among those least likely to be affected by recent developments relating to new foods and food analogs.

2) Not all of the products being developed will displace existing commodities. They may, in some cases, create new markets. New beverages and artificial flavors, for example, may fall in this category.

3) Food habits are remarkably sticky. This means that recent trends in consumption are likely to persist, and

4) Stickiness in food habits is frequently reinforced by rigidities in laws or regulations pertaining to food. Such laws or regulations may be employed in such a way as to inhibit or slow down the rate at which new foods, additives, or food substitutes can be introduced.

## Vulnerable Commodities Cited

The impact of new foods obviously will vary greatly among commodities and hence among agricultural regions as well. Fortunately from the standpoint of farmers in this region, the commodities most seriously threatened by the development of substitutes are not those of major importance in the Northeast.

I find it useful to divide agricultural commodities into three groups on the basis of their vulnerability to substitutes. In the first and most vulnerable group, I include the fibers (cotton and wool), sugar, and butterfat. These commodities already have faced serious competition from substitutes and will continue to do so. The technology of producing the substitutes is known and tested; plant capacity has been developed (and probably is excessive in the case of synthetic fibers at present), and the substitute products have gained consumer acceptance.

We are fortunate in New York that only a relatively small and probably declining fraction of our income from dairy products depends on the market for butterfat. By offering the consumer butter in different forms, and perhaps by permitting butter to be mixed with other products so as to improve its characteristics, dairymen might be able to hold or increase their share of the total market for fats and oils. But it is difficult for me to be very optimistic about the future prospects for butterfat. Whatever quantities we produce as a by-product of fluid milk operations can be sold at some price, but probably not one that is attractive to producers. Butterfat simply cannot compete on a price basis with vegetable oil, which will continue to be available as far in the future as I can see, at prices averaging no higher than 10 to 12 cents per pound. Production of oilseeds is expanding rapidly both in the United States and abroad. Oilseeds are now crushed mainly for animal feed, and the oil is largely a by-product of the oilseed meal industry. Since the demand for vegetable oil has not risen as fast as the demand for meal, vegetable oil has become a surplus commodity in recent years and is likely to remain so.

## Supplements for Feed

There is a second group of commodities which I believe may encounter increasing competition from new products. In this group, I include protein supplements for livestock feed, and certain beverages, including coffee and fruit juices, especially citrus juice, but not fluid milk. Synthetically produced forms of amino acids and cheap sources of nitrogen such as urea and possibly high-protein grains may, over the next decade, replace increasing quantities of oilseed meals which now go largely into livestock feed. It probably will take at least five years to improve yields of high lysine corn, which has been grown experimentally in the Midwest, but such a development could alter the demand for soybean meal. If this occurs, much of the present supply of oilseed meal would become available for conversion into soy flour or spun soy protein. Moreover, dairy animals apparently can be fed successfully on combinations of purified carbohydrates, urea, and ammonium salts. There is also at least a remote possibility that we may derive some of our feed ingredients from petroleum during the next 15 years. Such developments could radically alter the sources of nutrients and possibly the optimum location, character, size, and type of facilities required to produce or mix animal feed, although probably not within the next decade.

The ability to synthesize products that compete directly with orange juice has been clearly demonstrated in the past few years. I see no reason why the same techniques cannot be used to produce substitutes for other fruit juices, including grape juice and possibly even coffee. Again, it is fortunate that, except for grape juice, these products are relatively unimportant in New York.

## Soy Products No Threat

In the third group of commodities which I think are least vulnerable at present to possible displacement by new products I have included fruits, vegetables, meat, eggs, and fluid milk. My optimism with respect to the market prospects for these commodities is based partly on the persistence of food habits (which I shall be discussing in a moment), and partly on recent trends in production and sales of potential substitute products.

The products that have attracted most attention recently are potential meat substitutes derived from vegetable protein. Unquestionably more soy products will be produced and used over the next decade as thickening and binding agents and as a substitute or extender for meat in frankfurters, chilis, meat loaf, and perhaps some types of frozen dinners. But one must keep the sales of these products in perspective.

They now account for only a fraction of one per cent of meat sales. Even if the sales of these products continue to rise at the compound rate of 10 per cent per year, the total amount of meat displaced by these products in 1975 would still amount to less than one per cent of the combined current production of beef, pork, and poultry meat. The author of a recent article in Food Engineering emphasizes: "The task of converting inexpensive soy protein into acceptable food products is quite formidable. While great strides have been made, problems relating to taste, appearance, texture, and flavor must still be overcome."[1] Furthermore, not all these products are cheap when processing development costs are included, although the raw materials may be relatively inexpensive. For these reasons, I do not consider soybean products a serious threat to the livestock industry in the United States, at least during the next decade.

## Consumer Food Habits

My reason for placing fluid milk, cheese, and eggs in the least vulnerable group is based partly on the lack of readily acceptable substitutes and partly on the persistence of food habits. Per capita consumption of both fluid milk and eggs has been declining for more than a decade, and these trends are unlikely to change. But the loss of markets for these products has not been due to the development of specific substitutes or analogs, but rather to long-run changes in consumer food habits, population characteristics, and an abundant supply of other forms of protein. Soy products will continue to compete with nonfat dry milk, but I doubt that soy milk will become a major competitor for fluid milk in the United States during the next 10 to 15 years. Its potential market probably is greater overseas than in this country.

Recently, the U. S. Department of Agriculture has prepared estimates of per capita consumption of major food groups for the year 1980. These estimates reinforce my conviction that recent trends in food consumption are likely to persist. During the next 15 years, according to the USDA estimates, we can expect increasing per capita use of beef, poultry meat, and vegetable fat, about the same per capita use of potatoes, other vegetables and fruits, and declining per capita consumption of pork, eggs, fluid milk, animal fat, and possibly wheat.[2] The major type of substitution implied by these forecasts is continued displacement of one type of agricultural commodity by another such as the substitution of vegetable for animal fat and beef or poultry for pork rather than the substitution of synthetic products for those of agricultural origin or vegetable for animal protein.

## Rigidity in Laws

Some of our laws and regulations relating to food are almost as resistant to change as are food consumption habits. One has only to recall how long it took to legalize the sale of colored margarine or to permit standardization of milk in New York to be impressed with the fact that the status quo has an enormous advantage.

1. John V. Ziemba, Let Soy Proteins Work Wonders for You, Food Engineering, Vol. 38, No. 5, May 1966, pp. 90-93.

2. F. F. Daly and A. C. Egbert, A Look Ahead for Food and Agriculture, Agricultural Economics Research, Vol. XVIII, ERS, USDA, p. 1-9.

Agricultural producers or those with vested interests in existing food products have become experts at fighting delaying actions. Less time probably will be required to change laws so as to permit selling new or substitute products in the future as the political influence of consumers rises in relation to that of agricultural producers. However, it will still take time to get laws changed. Furthermore, new products often require approval by the Food and Drug Administration before they can be introduced. The FDA, of necessity, must be cautious in approving new products. Natural food products also have a favorable image and many individuals are reluctant to authorize the use of additives which may change that image. All these factors will tend to delay or prevent changes in laws or regulations that might be required to permit marketing new products or adding ingredients to traditional ones.

## Ways to Remain Competitive

While I have tended to minimize the impact that the development of new products may have on agriculture in the Northeast, I do not want to leave the impression that these developments can be ignored. They do indeed present a challenge to those involved in agricultural production and marketing. Where there is an actual or potential threat of new products being developed to replace those traditionally supplied by farmers, producers may find it necessary to take various kinds of action in an effort to remain competitive. These may include assessing themselves more for research and promotion efforts, altering the characteristics of their product, perhaps modifying laws so as to permit combining or adding ingredients, providing assurances to processors or buyers of stable supplies, imposing more rigid and uniform quality standards, and pricing more competitively.

One of the important repercussions of new product development such as synthetic fibers or synthetic fruit drinks such as Tang or Awake has been to force producer groups to spend more for research and promotion to meet the challenge offered by large, integrated firms accustomed to spending millions of dollars each year on development and selling activities.

I have come to the conclusion, somewhat reluctantly, that farmers will have to spend more for such activities in the future if they are to remain competitive. Increased expenditures may be necessary simply to enable farmers to hold a share of the market. Society obviously benefits from new products and innovations, but there also is a price that must be paid. New product development in many cases simply results in proliferation of products with each one competing for a declining share of the market.

The net result may be further escalation of advertising expenditures and higher marketing costs generally due to product differentiation and the necessity of increasing shelf space in supermarkets to accommodate the increasing number of products. The consumer may have to put up with more commercials per hour of television and, in addition, will find it increasingly difficult to make rational choices from among the multiplicity of products offered.

## Uniform Characteristics

The development of new products also is likely to reinforce current demands on producers to do something about unstable supplies and to offer commodities with more uniform characteristics tailored to the needs of buyers. Clearly, agriculture has been at a competitive disadvantage in relation to industry in providing assured supplies of products with uniform characteristics.

This is one reason why synthetics have replaced natural fibers despite the higher cost of some man-made fibers. Likewise, manufacturers of soups, or other processed foods requiring meat or meatlike products, may prefer to use spun soy protein rather than meat because of uniform quality, fat content, size, and shape.

Pricing also becomes more critical as substitute products become available. Price obviously is not the only consideration in choosing from among alternative products, but it is difficult to convince buyers that milk fat, for example, must be used when vegetable fats are available at a fraction of the cost. Cotton producers have learned that over-pricing cotton can lead to a serious loss of markets. Nonfat dry milk also may lose sales to soy flour or other products if it is priced too high.

## Political Implications

There is an obvious political implication to the statement just made with respect to commodity pricing. Government support prices, if maintained at too high a level, will limit sales and invite the development of substitute products. Some of our support programs, especially for cotton, have had this effect in the past.

Where the demand for a commodity is very responsive to price changes (i.e., when the demand is price-elastic) there is every advantage to both producers and the government to permit prices to fall so as to encourage consumption and then to make up the difference between that price and whatever level of returns is politically acceptable by means of a direct payment.

Such a policy clearly is preferable from the point of view of producers to one that involves maintaining relatively high market prices accompanied by production controls or a government storage and diversion program. Recent farm price support legislation has moved away from the concept of high supports for grains and cotton toward more flexible pricing accompanied by the use of direct payments.

If we are to continue to support the incomes of dairy farmers, a similar change in policy might have some advantages from the standpoint of those producing and handling dairy products.

### New Demands for Aid

The development of additional substitutes for farm commodities also may lead to new demands for government assistance to agriculture in those areas adversely affected. Government aid could take the form of subsidized prices or direct payments as previously indicated, or it might be in the form of payments for diverting land to alternative crops with possible indirect effects on other producing areas.

For this reason, I do not think one can view the problems of cotton, butterfat, or possibly citrus, sugar, and coffee in isolation. Any diminution in the demand for these products could set in motion a chain reaction that could adversely affect producers in other areas as well, especially if those directly affected seek to produce alternative crops or ask for assistance from the government in trying to compensate for lost markets.

## CONCLUSIONS

The types of substitution that have had the greatest impact on agriculture in the Northeast during the past two decades have been the substitution of one type of input for another (for example, fertilizer and machinery for land and labor); the substitution of one type of agricultural commodity for another (such as vegetable for animal fat); and the substitution of products grown in one area for those produced in another (for example, lettuce grown in California for that produced in nearby areas or eggs in the Southeast for those in New England). These types of substitution probably will continue to be of more importance to agriculture in the Northeast--at least during the next 10 to 15 years--than the development of new types of food products or analogs.

Over a longer period of time, the development of new products could result in a slower rate of increase in the total demand for agricultural resources than we have experienced in the recent past, especially if there is widespread substitution of synthetic fibers or nonfarm sources of amino acids for products of agricultural origin. The substitution of vegetable for animal protein in human diets also could reduce the overall demand for agricultural inputs, since the efficiency with which animals convert plant to animal protein is only about 10 to 20 per cent. Society obviously can reduce the real cost of food by consuming protein more directly from plants rather than growing plants to feed to animals and then consuming the protein in the form of animal products. I suspect, however, that the substitution of one form of protein for another in animal feed will be more important during the next decade than the substitution of vegetable for animal protein in the diets of U. S. families. Overseas markets could become an important outlet for products derived from vegetable protein if they can be provided at low cost in a form widely acceptable to consumers in food-deficit countries or can be combined with existing foods as additives or extenders.

## Innovative Environment

The indirect effects of new-product development may be more important for Northeastern agriculture than the direct effects. Substitutes will continue to have the greatest impact on the demand for fibers, animal fat, sugar, certain types of beverages, and possibly soybeans. Changes in demand for these commodities will affect producers in the South and Midwest more directly than in the Northeast, but the adjustments forced by changes in demand for crops which they now produce could result in increased interregional competition for farmers in this area.

Finally, one should not overlook the positive contributions which an innovative environment may have on agriculture as well as consumers. In some cases, producers have gained additional markets by learning how to take advantage of new ingredients or by changing the form in which their product is sold. An innovative environment forces producers to reexamine their product and to alter its weaker characteristics. One learns to accept the fact that the natural product may not be good enough and sometimes can be improved. Cotton offers a prime example of how competitive pressures may change producer attitudes. Cotton growers have now accepted the responsibility of financing a research and promotion program which may ultimately help cotton to recapture some of its lost markets. Recently, scientists have learned to modify cotton in such a way as to improve its characteristics and to create end products that are superior to those previously available. The net result of this competitive process is that consumers will have available in the future an even wider array of products with improved characteristics from which to choose.

# FOOD ANALOGS--THE CHALLENGE OF THE FUTURE

David L. Call
H. E. Babcock Professor of Food Economics
Graduate School of Nutrition
Cornell University

It is a real honor for me to be asked to contribute my thoughts to this important conference. In accepting this assignment it was agreed that I would, to a certain extent, attempt to summarize the other papers of the conference. Therefore, my remarks are structured around an outline and are based upon both what I have learned in the last two days at this conference and my own biases. I should say at this stage that I do agree almost entirely with the points raised by my fellow economist, Dr. Robinson. I feel he has done an excellent job of putting this subject into the context of action programs and estimating the impact on Northeastern agriculture. My primary aim in the remainder of this paper is to identify some of the major challenges facing those in the food industry who wish to build upon the new forms of technology discussed during this program.

## Four Patterns of Use

It is possible to identify four patterns of use for protein materials, which are the raw product from which food analogs may be produced. It is not important to distinguish between isolated soy protein, fish protein concentrate, leaf protein, or protein from petroleum. In essence, these isolated proteins all form a class of raw materials which, I feel, we can discuss as a group. It should be recognized that they are not comparable with respect to functional and nutritional characteristics.

1) Substitution for Existing Ingredients. One of the major uses of these protein materials is in the substitution for existing ingredients in traditional foods. The substitution of an isolated soy protein or a concentrated soy protein for non-fat dried milk or casein in the bakery industry is an example. To a large extent, the substitution of these products for existing ingredients is based primarily on its functional characteristics and on the economics of the substitution. When a soy protein is used in sausage, to a certain extent it is substituting for an existing ingredient, but it is important to remember that the

protein is going in there, not because of nutrition, but because of the functional characteristics of fat absorption and its influence on the final product. I think most would agree that this pattern of use makes up the largest current market for these protein materials. I think it is also important to remember that to a large extent the ultimate consumer is unaware of this substitution. The decision is made not on the basis of consumer acceptance but on the basis of economics or the functional characteristics of the product to be substituted. The selling job on the part of the manufacturer of these products has been directed at the manufacturer of the food product. In other words, for this pattern of use to be successful it has been necessary to sell the manufacturer not the consumer.

2) Creation of New Food Products. The second pattern of use for these protein materials is the creation of new food products that are either all new or are patterned after existing foods. This use is the one that creates the most excitement and generates the most publicity. So far, this has been a relatively small market in terms of sales dollars, and almost non-existent in terms of profit dollars. We have been told here in this program that really we have at hand a new package of technology that will make it feasible to design a completely new class of food products with characteristics, in many cases, quite similar to products already existing in the market. To a certain extent, it is unfortunate that many of the products that have been developed are imitations of existing products. This is a natural course of events, since it is much easier to sell a product--even an imitation or "synthetic" product--that is in a form recognized by the consumer. The alternative is to try to create a totally new market for a completely different food, an expensive and risky situation. It appears to me that the products most likely to succeed in this use pattern will be those aimed at a highly specialized market, at least in the beginning, and certainly they will have to carry a fairly high retail price.

I think it is important to remember that the selling job for these products is completely different from the selling job for products with the pattern of use described earlier. With these products it will be essential to sell the consumer. Trying to sell the consumer or to persuade the consumer to buy a new product, or an almost new product, will be quite different from trying to sell a manufacturer on the advisability of changing ingredients. I would also include in this category the development of nutritional supplements; that is, new food products developed for a specific nutritional purpose. This would include the much discussed need for high-protein nutritional supplements in the less developed areas of the world, which I will touch on later.

3) Blending with and Extending the Supply of Existing Food Products. The third major use pattern, which has not been discussed a great deal in this conference, would be use of these protein materials in blending with and extending the supply of existing food products, particularly animal products. Some have referred to this as "shooting the bull." For example, if it is possible, as some maintain, to add 25 per cent of one of these protein materials to a frankfurter and reduce the cost 50 per cent without the consumer knowing the difference, this is extending the existing supply of an animal product. Obviously, this will not be permitted in many parts of the United States because of the existing

regulations. It should be abundantly clear after Dr. Quackenbush's paper yesterday that even if it was technically possible to extend fluid milk, that is, to combine one quart of fluid milk and one quart of water, plus some protein and other materials, and come up with a product that has the taste and functional characteristics of milk, this would not be legal in the United States.

I think that this use pattern may have the most potential in the overseas markets. Here again we have a different selling. In this case we are not selling the consumer; we are again trying to persuade a manufacturer to change his existing practices, but, more importantly, it appears we will have to be selling a regulatory agency. It will be necessary to change existing regulations, and I think such changes will be very slow in coming about in the United States. But, as I will point out in a minute, I think there are many possibilities outside the United States for extending the supply of animal products through this method.

4) Nutritional Enrichment. The fourth general pattern of use is nutritional enrichment. That is, these protein materials are mixed with existing food products primarily to improve the nutritional quality of the product. I think this is a different type of use from the mere substitution for existing ingredients based on functional characteristics. There has been some discussion of amino acids supplementation, the addition of soy flour to bread, and other forms of nutritional enrichment. This again is a pattern of use that has received a great deal of attention with respect to the overseas market.

## Challenges and Opportunities

It should be obvious from the above description of the potential patterns of use that many challenges and opportunities will face the food industry in the future. One of the unique things about this technology is the multitude of use patterns that one can visualize. Unfortunately, it is too early in the development of this technology to be able to accurately predict the impact on agriculture and on the consumer of the many potential uses of the products that may flow from this technology. In attempting to categorize the various challenges facing those interested in this part of the food industry, I propose to discuss it primarily from the standpoint of the marketplace. First, I should like to discuss the major challenges facing us in the domestic market, then briefly mention the other developed areas of the world, and finally the less developed areas of the world.

1) The Domestic Market. The first major challenge facing those attending this conference, and others interested in the possibilities of this new bundle of technology, is to ensure continuation of the research necessary to extend even further the frontiers of technological development in the face of very uncertain pay-offs. Investment of money in research is always risky, and in this area of research it will be still riskier. Because the markets have not been clearly defined, successful returns are uncertain. Many people in the food industry will be tempted to put their research dollars into safer areas where there is a more certain pay-off. Universities and the government will also be tempted to follow a similar course and to invest those dollars where there is a greater

public demand for a research effort. Also, the universities and the government, I feel, will be under increasing pressure from the established segments of the food industry not to put research money into this area because of the threat of potential competition. I think it would be very unfortunate if this course of action were followed.

The second major challenge facing us in the domestic market is to develop a market-oriented point of view on the part of the manufacturers of both the protein materials and the ultimate products. To a large extent, the current emphasis in the industry has been on production. This is traced directly to the major pattern of use, which has been the substitution for existing ingredients. To sell meat extenders, bread additives, replacements for casein, and so on, it has not been necessary to emphasize marketing rather than production. The major challenge in this area is to identify the needs of the marketplace and to structure and develop the technology necessary to meet these needs. Hopefully, the industry will attempt to develop a whole new class of food products that will rely more upon innovation than upon imitation. Those with experience in the food industry know that it is much easier to develop interesting food products in the laboratory than it is to bring a dollar down to the net profit section of the balance sheet with those same products in the marketplace. A market-oriented point of view is going to be essential if the dollars are to be brought to the profit section.

### Innovation in Food Industry

The third major challenge has been well discussed by previous papers in this conference. I refer to it as the maintenance or development of an environment that will permit innovation in the food industry. It is obvious that existing government regulations, set up primarily as a form of protection, now hinder or prohibit developmental efforts. I think all food manufacturers should face this challenge. Since at present they may not anticipate using this new bundle of technology and materials, their first inclination may be to protect their established position. In the longer run, the food industry will benefit if a more realistic climate that encourages innovation is established. I think it should be mentioned that the Food and Drug Administration must enforce existing laws, and that enforcement procedures are stated in the law. People should not look upon the Food and Drug Administration as the culprit who is not permitting innovation in the marketplace. It is possible to change these laws, and when this is done I would expect a changed attitude toward the Food and Drug Administration. It is important to convince people that nobody is really challenging the future of animal agriculture in this country. Unfortunately, because of the undue amount of publicity given to some products, this impression has been transmitted to many people in various segments of animal agriculture. An environment that permits innovation will in the long run benefit animal agriculture as much as it will benefit those who wish to develop either new food products or human uses for existing protein materials.

2) Other Developed Areas of the World. To a certain extent, industry and others interested in this area of work will face some of the same challenges in

the other developed areas of the world that were just outlined for the domestic market. If profitable markets are going to be developed in these countries--for example, Japan, Italy, West Germany, France, and Great Britain--it will be necessary to conduct further research to develop products suited to the needs of the consumer in those markets. Again the likelihood of pay-off for this research will be uncertain. The regulations with respect to the development of new food products may be completely different from those faced in the United States, and probably they will be different in every country. One possible major difference between these countries and the United States should be kept in mind. Many of these countries now import much of their animal protein. This indicates to me that the market might be much more receptive to innovations along the line mentioned earlier, that could lead to the extension of the supplies and to reduction in the price of animal protein products. This would be particularly true in markets where the existing use patterns are centered around a prepared form of animal protein that is often highly seasoned (for example, in Italy). I cannot emphasize too much the importance of a marketing emphasis on the part of industry as it attempts to develop products for these markets.

3) The Less Developed Areas of the World. It is clear that the greatest challenge facing those interested in food lies in meeting the needs of the less developed areas of the world. Earlier in this conference the protein gap facing many areas of the world was outlined. It is clear that there is a protein gap in many areas of the world. It is not possible to quantitatively define the nature of this so-called protein gap, but it is safe to say that, for many people in the world today, food intake does not provide the amount of protein that nutritionists consider desirable. Obviously if there is a shortage of protein in many areas of the world and if we have new technology with which to manipulate new protein materials, there should be many possibilities. There are many possibilities but there are also many challenges. First, a comment seems in order on one statistic that was quoted in an earlier paper. At that time it was said that 68 per cent of the people in the world are hungry, and that within 10 years the figure will be as high as 73.5 per cent. This is putting a little too much emphasis on the right-hand side of the decimal point when we are not even sure what is on the left-hand side. I maintain that nobody knows how many hungry people there are in the world because no nutritionist has been able to quantitatively define hunger. We do know that there are a lot of people with nutritionally inadequate diets in the world, but we do not know, and I don't think it important that we know, whether it is 68 per cent or 65 per cent or 50 per cent or 80 per cent. There is a severe problem, and it is a challenge to all of us to attempt to meet the needs of these people. Therefore, I feel that the first major challenge facing us with respect to the less developed areas of the world is to develop a true understanding of the calorie-protein malnutrition problem. Nutritionists and medical people have done quite a bit of research in this area; they can clinically define the symptoms of protein malnutrition and can tell us with great preciseness what nutrients are needed. But, we have not, country by country, determined the true social, political, economic, and nutritional causes of protein malnutrition. Until this is done, it will be extremely difficult to cure protein malnutrition or to contribute to the solution of the problem.

## Protein Gap Linked with Poverty

In many cases, when we speak of the protein gap we are really talking about a poverty gap. It appears that the shortage of protein goes hand in hand with a low standard of living. Not many people in the less developed areas of the world today are waiting to buy protein. In other words, there is not a true market demand for protein. Remember people eat food, not protein. People do not eat fish protein concentrate or soy protein isolates. The real challenge, therefore, is to determine how to get more protein into people who have no money to pay for it, and many of whom do not even know that they need it.

The second major challenge we face in meeting the problems of the less developed areas is tied in fairly closely with this. I think it is necessary to develop a research framework that includes nutritionists, food scientists, and social scientists, so that the research efforts will be directed toward the real problem outlined above. This multi-disciplinary approach to the problem should aid in the development of products and procedures acceptable to the people, and should hopefully contribute to the long-run solution of the protein-malnutrition problem. The type of protein material should not influence this type of research. The choice of the source of protein, be it fish protein concentrate, or soy protein, or cottonseed protein, or some other form, should be made after attempts to determine the best way to introduce more protein into the diet. I believe the potential role of protein supplements has been overemphasized, and the role of existing food products in expanded supply has been ignored.

## Commercial Success Uncertain

The third challenge is to find a continuing source of funds to finance the types of research described above. It will be very difficult to convince industry that they should invest their scarce research dollars in the analysis of a problem when the prospects of commercial success on protein products are extremely uncertain. In essence, we face a problem of attempting to develop and sell a sophisticated product to a group of people with little money and, in many cases, with little incentive to purchase that product. This is not the sort of situation in which one would expect to make high profits; in fact, profits are likely to be subnormal for many years. This is a completely different situation for the American food industry, which has been selling sophisticated products in an affluent market. I believe that the United States government and the governments of countries that want our help must help to finance this research effort. This will be particularly important in the early stages of development, and if it is not done then I do not think that research and development can be expected to continue. If industry must depend upon partial government subsidization of research efforts, we face another major challenge. We should develop some sort of agreement between industry, universities, and the United States and foreign governments as to the proper role of each one in developing protein resources on a country-by-country basis. The problem is so urgent that we must attempt to prevent unnecessary duplication. Also, I consider it very important to clearly state the rules of the game, so the participating agency knows it is on sound ground. We cannot expect United States industry to invest research dollars in these areas if there is a threat that at some time in the future the United States government or the local government may force them out of the market with the introduction of a competing product or through other unfortunate courses of action.

## SUMMARY

At any time an industry develops new technology and new raw materials, many challenges are posed. I think it is extremely important that we accept this challenge as another potential large step forward in our continuing efforts to better feed the people at a lower net cost. We should not view these developments as a threat to the existing system. The tremendous food complex in this country was built upon the ability of products to withstand the competitive forces in the marketplace. We did not get where we are by ruling out or making illegal new forms of technology. I hope that the marketplace will continue to be the final judge of how well those in this room and others in the food industry accept the challenge of this new technology.

With respect to the less developed areas of the world, we have not provided an answer to the protein problems that face these areas. The new ideas discussed here are added to an already large warehouse of technological knowledge of how to produce more food, how to store food better, how to produce better food products, and how to produce more nutritious foods. This warehouse is just beginning to be used. Our agricultural surpluses may be gone, but this surplus of technological know-how is still growing. The challenge we face is to have the foresight and the resources to capitalize on this tremendous surplus, so we can help the less fortunate people in other areas of the world.

# CONFERENCE COMMITTEE

Robert F. Holland, Chairman
Professor and Head
Department of Food Science

Nyle C. Brady
Director of Research
New York State Colleges of Agriculture
and Home Economics at Cornell University

Joseph F. Metz, Jr.
Assistant Director of Research
New York State Colleges of Agriculture
and Home Economics at Cornell University

Donald W. Barton
Director, New York State Agricultural
Experiment Station at Geneva

Willard B. Robinson
Professor and Head
Department of Food Science and Technology
New York State Agricultural
Experiment Station at Geneva

William B. Ward
Professor and Head
Department of Communication Arts

Max E. Brunk
Professor of Marketing
Department of Agricultural Economics

## Facts About Cornell University and New York's Agriculture

Compared with some other American universities, Cornell, with its 15 schools and colleges, is of medium size. Listed on its rolls are more than 14,000 students. (One out of five are in the New York State College of Agriculture, the second largest college in the university.) The university's faculty and staff on the Ithaca campus number about 6,500.

Cornell is a national and international institution. Its students come from every state in the Union and from 82 foreign countries.

The university's activities are mainly centered on the Ithaca campus, comprising more than 90 major buildings on several hundred acres. It has a medical college and a nursing school in New York City and an aeronautical laboratory in Buffalo. Cooperative Extension is located in 56 counties of the State. Cornell also administers the New York State Agricultural Experiment Station in Geneva.

New York's farm income reaches close to $1 billion a year. More than 2,500 firms sell $800 million worth of raw materials each year to farmers in the Empire State. Seventy thousand firms transport, process, and package farm products—a $2 billion industry that employs more than 200,000 persons.

Published by the New York State College of Agriculture, a Statutory College of the State University, at Cornell University, Ithaca, N.Y.